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CONTENTS

A Study of Weed Eradication with 2,4-D in Lawns, Vacant Lots, and Pastures.. *By Renato I. Capinpin and G. O. Ocfemia* 239

Effects of Photoperiod upon the Upland Rice Plant Variety Inintiw..... *By Burton T. Oñate and Rafael B. Espino* 256

The Growth and Development of Philippine and Murrah Carabaos and Their Crossbreed..... *By Fidel F. Reyes* 271

A Photochemical Reaction of Some Vegetable Oils with Chlorine Gas..... *By Julian Banzon* 279

Studies on a Photochemical Reaction of Coconut Oil with Chlorine Gas..... *By Julian Banzon and Felix K. Maramba, Jr.* 289

The Performance of Five Varieties of Lowland Rice..... *By Valeriano C. Calma and Miguel D. Paguio* 298

A Comparative Study of Certain Characteristics of First-Year Students in Agricultural, Rural, and Academic High Schools..... *By Francisco M. Sacay, Chan Meesukh, and Praves Shribhibhadhna* 305

Broodiness among Los Baños Cantonese Layers..... *By F. M. Fronda and Precillano Campos*.... 311

College and Alumni Notes..... 315

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A STUDY OF WEED ERADICATION WITH 2, 4-D IN LAWNS, VACANT LOTS, AND PASTURES[1]

RENATO I. CAPINPIN AND G. O. OCFEMIA
Of the Department of Plant Pathology

WITH THREE TEXT FIGURES

Weeds increase the cost of crop production. They furnish alternative hosts to some insect pests and enhance army worm destructiveness to rice and sugar cane because the crowding effect of the weeds delays hardening of the leaves of these crops (Uichanco, 1928). Weeds also furnish secondary hosts to many plant pathogens, holdovers of viruses, and wild hosts of their insect vectors.

In pastures the fast-growing and rank nongraminaceous weeds crowd out the grasses. A weed like *Lantana camara* Linn. produces an impenetrable thicket and is reported by Sanders[2] as a cause of cattle poisoning in the southern United States. In fresh-water lakes and rivers used for irrigation in the Philippines, the spread and growth of water hyacinths, sedges, and other water weeds obstruct the flow of water and make the place ideal for the breeding of mosquitoes. On lawns and golf courses nongraminaceous weeds mar the beauty which the uniform growth of grasses gives.

Most Filipino farmers use the "gamas" method[3] of weeding. In lowland rice fields, weeds are controlled to a certain extent by flooding the paddies soon after the seedlings are transplanted. Flooding prevents the weed seeds from germinating, destroys the weed seedlings, and hastens the rotting of the roots of many weeds. These two methods of weed control, however, are inadequate; not all lands can be flooded, and the "gamas" method is ineffective and expensive.

Owing to the importance of weed eradication and hence of the need for a more effective and inexpensive method, the writers tried the use of the organic compound 2, 4-dichlorophenoxyacetic acid, referred to as 2, 4-D, which was recently introduced as a weed killer [4] of the plant-regulant type and is selective in its effects (Klingman, 1946).

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[1]Experiment Station Contribution No. 1483, presented by the senior author as thesis for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, March, 1948. Prepared in the Department of Plant Pathology under the direction of the junior author.

[2]Sanders, D. A. 1946. Lantana poisoning of cattle. Florida Agric. Exper. Sta. Press Bull. 620: 1–4. *illus.*

[3]Pulling up weeds by hand with the aid of a crude tool.

[4]E. I. Du Pont de Nemours & Co. (Inc.) 2, 4–D weed killer available in both powder and tablet form; Du Pont weed killer controls many undesirable weeds; Karmex weed killer, small tablets of 2, 4–D. Agricultural News Letter **14** (3): 42–45. 1946.

The test with 2, 4-D for destroying weeds, especially the nongraminaceous species, on lawns, vacant lots, and pastures; its effect on the species treated; and the duration of its lethal effects on the weeds was made in the College of Agriculture campus and in Los Baños, Laguna, from December, 1946, to January, 1948, a period of about thirteen months.

MATERIALS AND PROCEDURE

Eight-square-meter lots were staked off on lawns, vacant lots, and pastures that had mixed growths of grasses and nongraminaceous species of weeds.

Aqueous solutions of "Dox Weed Killer"[5] containing 100, 200, 500, 1,000, and 2,000 parts per million of the substance were prepared, using tap water. With a knapsack sprayer, each concentration was tested on every lot at the rate of 20 liters to 100 sq. m., or 1.6 liters to every 8 sq. m. Except when the species appeared tolerant of the chemical, only one application of one concentration was made to each lot.

The stage of development of the nongraminaceous species sprayed was noted, together with their response and that of the grasses to 2, 4-D. Weed counts were made before treatment and after a lapse of 40 to 60 days.

A 20-per-cent dust was prepared with wood ash as diluent and applied with a duster (Uichanco, 1931). Care was taken to cover the leaves of the weeds completely with the chemical.

Sugar-cane stools which were about eight months old were inoculated with the seeds of the root parasite *Aeginetia indica* Linn. and then the root parasite was treated with a 1,000 p.p.m. solution of 2, 4-D in its different stages of development.

Freehand sections were prepared of the stems, flower stalks, and petioles of treated species which showed the characteristic injury, and the histological effects of 2, 4-D on them were studied.

RESULTS AND DISCUSSION

Gross response to 2, 4-D of broad-leafed weeds

The effects of 2, 4-D on the treated plants began to appear in 6 to 12 hours. The effects were noted earlier on warm than on cool days. Although the plants were not killed outright, their metabolic processes seemed greatly impaired as shown by the changes in their normal habit.

The immediate effect of 2, 4-D upon nongraminaceous weeds was the wilting appearance of the leaves and the bending and twisting of the stem (fig. 1). The leaves bent at the petioles, drooped to the side of the stem,

[5]The "Dox Weed Killer" manufactured by the California Spray-Chemical Corp. at Richmond, California, contains 60 per cent by weight of the active ingredient 2, 4-dichlorophenoxyacetic acid.

and then twisted counterclockwise. The twisted petioles appeared crisp, a severe epinasty was exhibited by the youngest visible leaf of the plant, and the stems of both woody and herbaceous plants showed the same effect although in herbaceous plants the injury appeared earlier than in woody plants.

Fig 1.—The appearance (left to right) of *Mimosa pudica* Linn., *Amaranthus viridis* Linn., and *Amaranthus spinosus* Linn. 14 days after the application of a 2, 4-D spray of 1,000 p.p.m. Note the twisting of the leaves, stems, and flower stalks, and the swellings on the lower part of the stems and on the roots. *Photograph by G. Laforteza.*

The weeds that were in bloom at the time of treatment with 2, 4-D dropped their flowers. The flower stalks bent, twisted (fig. 1), and finally died. The fruit buds also dropped off after the treatment, although fruits of *Lantana camara* which were on their way to maturity when the weed was treated were not injured but continued to grow to maturity.

Grisby (1946) in Michigan noted that the pollen production of ragweed can be stopped with 500 p.p.m. spray of 2, 4-D without causing immediate death to the plant and that this weed can be totally killed by a single application of 1,000 p.p.m. solution of 2, 4-D.

In their weed-control trial the writers noted that 24 hours after treatment with 2, 4-D solution, the leaves of nongraminaceous weeds first turned light green and later yellow. Six to 20 days after treatment, both leaves and stems turned brown and dried up. Plants killed by 2, 4-D

had reduced fibrous roots and formed nodule-like growths on the main roots (fig. 1). The roots appeared shriveled and the pith deteriorated in a short time.

Effects of 2, 4-D on grasses

Unlike the broad-leafed weeds, grasses seemed not much affected by 2, 4-D, except on warm days and when excessive amounts of the solution at concentrations higher than 1,000 p.p.m. were applied on them. The effect of 2, 4-D upon grasses was the brownish discoloration on the leaves starting from the margins of the leaf blades. No matter how their leaves were injured, however, the grasses recovered in three to four weeks. The 2, 4-D solution was probably not absorbed by the grasses because their stems and roots did not show much injury, and where the brownish discoloration of the leaves occurred, owing perhaps to the acidity and the bleaching effects of the solution, recovery took place in a few days. The following four grasses were injured by 2, 4-D solutions in concentrations higher than 1,000 parts per million:

Scientific names[6]	*Common names*
Cynodon dactylon (Linn.) Pers.	Kawad-kawad
Paspalum conjugatum Berg.	Kulape
Imperata cylindrica (Linn.) Beauv. var. *Koenigii* (Retz)	Cogon
Eleusine indica (Linn.) Gaertn.	Bakis-bakisan

The optimum concentration of 2, 4-D for weed eradication

Marth and Mitchel (1946) in Maryland found that the common lawn weeds plantain (*Plantago lanceolata*) and dandelion (*Taraxacum officinale*), both of the family Compositae, can be killed effectively with 1,000 p.p.m. 2, 4-D applied at the rate of 5 gallons to every 1,000 sq. ft. (18.9 liters to every 93.02 sq. m.).

Ryker and Brown (1946) in Louisiana controlled several species of weeds in the rice field with a 1,000 p.p.m. solution of 2, 4-D applied at the rate of 1,000 gallons to the acre (3,780 liters for every 404.7 sq. m.). In 1947 Ryker found the same concentration of 2, 4-D very effective against the three rice weeds indigo, *Sesbania macrocarpa* Muhl., curly or frizzly indigo, *Aeschynomene virginica* (Linn.) B.S.P., and Mexican weed or bird's-eye, *Caperonia castaneaefolia* (Linn.) St. Hil. when applied one to two weeks after flooding.

In the present study, it was noted that as the concentration of the spray was increased up to 1,000 p.p.m., the lethal effect on many species of broad-leafed weeds also increased. With *Elephantopus spicatus* and *Elephantopus scaber* of the family Compositae as indicators of the lethal

[6]Determinations of all weeds used in this work were by Mr. Mamerto D. Sulit, Senior Scientist, Philippine National Museum.

action of the 2, 4-D, varying concentrations of the herbicide were sprayed on the prepared lots from January 10 to March 10, 1947, and then from October 12 to December 22, 1947. The results of this experiment given in tables 1 and 2 show that an increase in the concentration of the spray up to 1,000 p.p.m. increased proportionately the percentage of the weeds killed. An aqueous solution of 1,000 p.p.m. of 2, 4-D gave a 100-per-cent destruction of the weeds whether in the experiment in January to March, 1947, or in the treatment made in October to December, 1947. Concentrations of 2, 4-D above 1,000 p.p.m., however, produced results no better than those produced by the 1,000 p.p.m.

The lowest concentration of 100 p.p.m. tested was also injurious to *Elephantopus spicatus* and *E. scaber;* however, only a small percentage of destruction was produced and the injured plants recovered fully 30 to 45 days after the treatment.

Tables 1 and 2 also show that *Elephantopus scaber* was easier to kill with 1,000 p.p.m. 2, 4-D than *Elephantopus spicatus.* Even with a 500 p.p.m. 2, 4-D solution, 93.3 per cent of the *Elephantopus scaber* treated were killed. This percentage was quite high for a single application of 2, 4-D solution. In order to maintain lawns free from weeds, two to three applications of 500 p.p.m. at intervals of about 25 days seem advisable.

Tables 1 and 2 also indicate that the stage of development of the plant seems to have no relation to the effectiveness of 2, 4-D as a herbicide. The weeds sprayed in January to March, 1947, were already in the flowering stage when those treated in October to December, 1947, were still in the preflowering stage. The percentage of weeds destroyed by the 1,000 p.p.m. solution of 2, 4-D was the same in both periods of treatment as indicated by the test plants *Elephantopus spicatus* and *E. scaber.*

Brown and Holderman (1947) report a considerable reduction of alligator weed, *Alternanthera philoxeroides,* in sugar-cane fields sprayed with 2,000 p.p.m. of 2, 4-D at the rate of 5 gallons to every 1,000 sq. ft. (18.9 liters for every 9,302 sq. m.).

Brown and Carter (1946) state that several species of plants are readily killed by 2, 4-D. Of the species enumerated by these authors, the water hyacinth (*Piaropus crassipes* [Mart]), coco grass (*Cyperus rotundus*), dayflower (*Commelina*), pennyworth or dollar grass (*Hydrocotyle umbellata* Linn.), and pigweed (*Amaranthus*), or their close relatives, thrive in the Philippines.

Sloans (1947) in Queensland found that the following weeds, also found in the Philippines, were killed upon treatment with 2, 4-D applied at the rate of 1 to 2 lb. of active principle to the acre (0.49 to 0.90 kgm. for every 404.7 sq. m.): goat weed *Ageratum conyzoides,* red pigweed *Portulaca oleracea,* and nut grass *Cyperus rotundus.*

The writers found in their experiment that the following 49 species of nongraminaceous weeds belonging to 17 families were killed by a single application of 1,000 p.p.m. aqueous solution of 2, 4-D:

Acanthaceae	
Asystasia gangetica (Linn.) Anders.	
Lepidagathis secunda (Bl.) Nees	
Amaranthaceae	
Achyranthes aspera Linn.	Dokot dokot, libai
Aerua lanata (Linn.) Juss	Apug-apugan
Alternanthera ficoides	
Alternanthera sessiles (Linn.) R. Br.	Boñga-boñga
Amaranthus spinosus Linn.	Urai
A. viridis Linn.	Kolites
Celosia argentea Linn.	Kindayohan
Cyathula prostata (Linn.) Bl.	Dayang
Stachytarpheta jamaicensis (Linn.) Vahl.	
Boraginaceae	
Heliothropum indicum Linn.	Hinlalayon
Capparidaceae	
Gynandropsis gynandra (Linn.) Merr.	Apoi-apoiyan
Commelinaceae	
Commelina benghalensis Linn.	Alicbañgon
Commelina nudiflora Linn.	Alicbañgon
Convolvulaceae	
Hewittia sublobata (Linn.) O. Kuntz	
Ipomoea cairica (Linn.) Sweet	Aurora
I. pes-tigridis Linn.	
I. reptans (Linn.) Poir	Kang-kong
Merremia hastata (Desr.) Hallier f.	
M. gamella (Burm.) Hallier f.	
M. vitifolia (Burm. f.) Hallier f.	
Compositae	
Ageratum conyzoides Linn.	Bulac manoc
Blumea balsamifera (Linn.) DC.	Sambong
Cosmos caudatus HBK.	Turai-turai, cosmos
Elephantopus mollis HBK.	Pawikan
E. scaber Linn.	Dila-dila
E. spicatus Aubl.	Dilang aso
Emilia sonchifolia (Linn.) DC.	Tagulinao
Erigeron sumatrensis Retz	
Synedrella nodiflora (Linn.) Gaertn.	Fantakuen
Vernonia cinerea (Linn.) Less.	Agas moro
V. patula (Ait.) Merr.	Bulac manoc
Cyperaceae	
Cyperus rotundus Linn.	Mutha
Kyllinga monocephala Rottb.	

Euphorbiaceae	
Acalypha indica Linn.	
Euphorbia hirta Linn.	Golandrina
E. thymifolia Burm.	
Labiatae	
Coleus blumei Benth.	Magana
Hyptis suaveolens Poir	Suob-kabayo
Piperaceae	
Peperomia pellucida HBK.	
Pontederiaceae	
Eichornia azurea Kunth.	Water lily
Portulacaceae	
Portulaca oleracea Linn.	Golasiman
Rubiaceae	
Borreria hispida	
Oldelandia corymbosa Linn.	
Paederia tomentosa Blume	Kantutay
Scrophulariaceae	
Scoparia dulcis Linn.	Damong Maria
Umbelliferae	
Hydrocotyle asiatica (Linn.) Urban	Takip-kuhol
Urticaceae	
Pilea microphylla (Linn.) Liebm.	

The following species of weeds were killed by a 20 per cent 2, 4-D dust:

Malvaceae	
Abutilon indicum (Linn.) Sweet	Malvas
Sida acuta Burm.	Escobang-haba
Urena lobata Linn.	Kolot-kolot
Tiliaceae	
Corchorus acutangulus Lau.	Pasao-luklukan

Weeds resistant to 2, 4-D

Although the seedlings of *Lantana camara* were easily killed by 2, 4-D, the mature plants were resistant to the herbicide. When treated, the mature shrub exhibited bending and twisting of the leaves and stems, and shedding of leaves and drying, but it recovered fully after a month. New leaves were produced but not at the same places from where the old leaves were shed. The new leaves differed in shape and size from the untreated leaves. The recovery of *Lantana camara* may be due to its woody nature, and the rapidity of its growth perhaps enables it to outgrow the proliferation of the leaf buds.

The tolerance of some weeds to 2, 4-D may perhaps be attributed to the nature and texture of their leaves. In *Mimosa pudica* and *Mimosa invisa* the leaves are small and waxy and are unwettable with the herbicide solution (fig. 1). Both of these species showed the effects of 1,000 p.p.m. of 2, 4-D in 25 days but recovered later. The treatment with the 1,000 p.p.m. solution of 2, 4-D was repeated 27 days after recovery but the plants grew again. A third application was made with a 2,000 p.p.m. of 2, 4-D but the

plants still recovered. A month after spraying the plants with a 2,000 p.p.m., a fourth application with a 5,000 p.p.m. 2, 4-D solution was made. In the repeated sprayings the younger stems dried up and their leaves dropped off. The older foliage and stems, however, were not much injured and the plants finally recovered. It appears that in the resistant species of weeds the application of 2, 4-D prevented the production of seeds because the flowers fell off when the plants were treated.

In addition to *Lantana camara, Mimosa pudica,* and *Mimosa invisa,* the following species, mostly Leguminosae (fig. 2), were resistant to the herbicide:

Leguminosae	
Alysicarpus nummularifolius (Linn.) DC.	Banig-usa
Calopogonium muconoides Desv.	Calopogonium
Cassia mimosoides	
C. occidentalis Linn.	Balatong aso
Desmodium capitatum (Burm.) DC.	Mani-manian
D. trifolium (Linn.) DC.	Pakpak lañgau
D. scorpiurus (Sw.) Desv.	
Indigofera suffruticosa Mill.	Tinatinaan
Euphorbiaceae	
Breynia cernua (Poir) Muell-Arg.	Matang-olang
Oxalidaceae	
Oxalis repens Thunb.	Taiñgang-daga

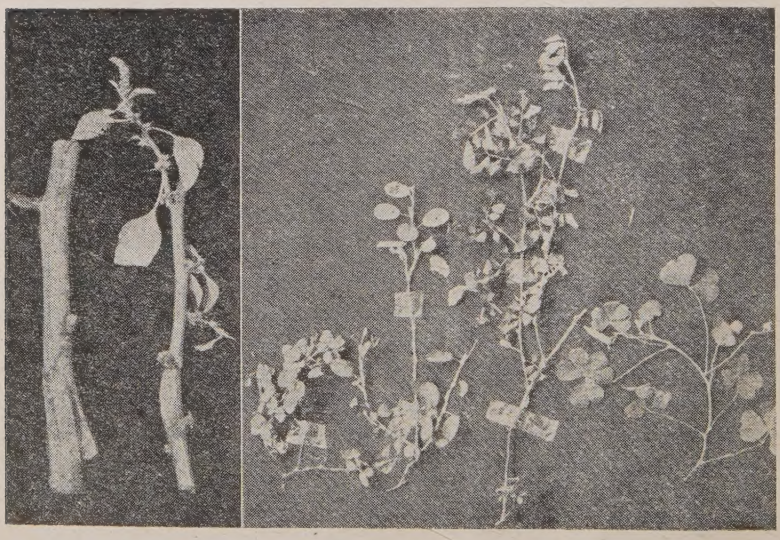

Fig. 2.—From left to right: Two portions of the stem of *Amaranthus spinosus* Linn. 14 days after the plant was sprayed with a 1,000 p.p.m. 2, 4-D solution showing the swelling and the cracking of the stem; portions of the stems of *Desmodium trifolium* (Linn.) DC., *Alysicarpus nummularifolius* (Linn.) DC., *Indigofera suffruticosa* Mill., and *Oxalis repens* Thunb., some of the species of nongraminaceous weeds resistant to 2, 4-D. *Photograph by G. Laforteza.*

The effect of 2, 4-D on Aeginetia indica Linn.

Drew and Helen[7] in Missouri found that *Cuscuta pentagona* Engelm that is parasitic on herbs, can be killed by 2, 4-D without causing much injury to the host plants. The selective action of 2, 4-D being known, the effective-

Fig. 3.—The effects of 1,000 p.p.m. 2, 4-D on the phanerogamic parasite of the roots of sugar cane, *Aeginetia indica* Linn. Upper panel shows the wilting flower stalks 24 hours after the application of the spray. Lower panel, left, shows the more pronounced bending of the sheats accompanied by twisting, right, of a bunch of *Aeginetia indica* killed by the spray of 1,000 p.p.m. 2, 4-D. *Photograph by Dr. Julian Banzon.*

[7]Du Pont Agricultural News Letter 15 (2): 1947.

ness of the solution was tested for killing the root parasite, *Aeginetia indica* without injury to the sugar cane.

On August 28, 1947, the bunches of shoots of *Aeginetia indica*, 2 to 5 centimeters high, emerging from heavily infected sugar-cane stools were thoroughly sprayed with a 1,000 p.p.m. of 2, 4-D. Within 12 hours the bending of the flower shoots (fig. 3, upper panel) was noted; in 1 week, the color of the shoots changed from red to reddish yellow; in 21 to 24 days, the whole bunch (fig. 3, lower panel, right) dried up; and 30 days after the parasite had completely dried up, new growths emerged. On examination of the roots of the sugar cane, however, it was noted that the new growths came from different parts of the stool. Each of the numerous minute seeds of the parasite evidently found a separate sugar-cane root on which to attach its seedling on germination. The shoots of the *Aeginetia indica* which did not get wet with the 2, 4-D solution because they had not yet emerged, were not affected. In other instances, some of the shoots which were sprayed when they were but a few centimeters above the ground and the upper parts of which were killed by the treatment produced outgrowths too. Treatment of the *Aeginetia indica* was repeated on September 30, 1947, when it was in the preflowering and flowering stages. The bending and twisting of the shoots of the plants in the flowering stage, and necrosis of the flowers occurred in two to three days (fig. 3, lower panel, left). The capsules in which the young seeds were already formed dried prematurely. On October 30, 1947, the whole bunch of the root parasite dried up (fig. 3, lower panel, right). Examination of the dead *Aeginetia indica* revealed that the root parasite rotted to the point of attachment to the cane roots although the sugar-cane roots were not affected. On December 12, 1947, new growths of *Aeginetia indica* appeared on different parts of the base of the infected cane plants, apparently from seeds which germinated late. When the parasite was about to flower, it was sprayed again with the same strength and dosage of 2, 4-D. Up to February, 1948, however, no further growths were observed either from the dried root parasite or from other roots of the sugar cane.

Inasmuch as 2, 4-D is a plant hormone, it was determined whether or not this substance could be applied to the sugar-cane leaves in quantities that on absorption by the host would affect the root parasite. The advantage of this application of the herbicide by way of the host is that under field conditions it is troublesome and difficult to locate the parasite when it is hidden by the foliage of the canes. For this purpose, a solution of 1,000 p.p.m. 2, 4-D was sprayed copiously on the leaves of the sugar cane. Care was taken not to wet the root parasite with the 2, 4-D solution. Repeated applications on parasitised sugar-cane stools, however, did not affect the development of the *Aeginetia indica*. Neither did the 1,000 p.p.m. concentration of 2, 4-D injure the leaves of the sugar cane. When applied directly to the parasite

at blooming time this concentration of the herbicide killed the plant down to its point of attachment to the root of the sugar cane.

The selective action of 2, 4-D on plants

When mixed growths of grasses and nongraminaceous weeds were treated with 1,000 p.p.m. 2, 4-D, only the nongraminaceous plants exhibited the deleterious effects which precede death. The grasses were injured only when 1,000 p.p.m. solution was applied copiously. Grasses injured by excessive amounts of 1,000 p.p.m. 2, 4-D, however, recovered in one to three weeks, depending upon the degree of injury and the weather conditions prevailing during and after the treatment. Concentrations higher than 1,000 p.p.m. also caused the appearance on the grass leaves of brownish discoloration.

The selective action of 2, 4-D on weedy lawns and pastures seemed to be due not so much to difference in physiological reaction to the ingredients of the herbicide as perhaps to the difference in morphological characters of the leaves and stems of grasses and of nongraminaceous species. Owing to the shape and surface of grass leaves and their position on the stem it is difficult to wet the leaves with the 2, 4-D sprays. As the grass leaf is linear in shape, its surface either smooth or waxy, and its position almost vertical, probably not much of the herbicide solution could get in to affect the physiology of the plant. The leaves of nongraminaceous species, however, are borne almost horizontally and the growing point is located apically and unprotected. The leaves are completely wet with the spray and a stable solid-liquid interphase of the spray droplet and leaf surface is formed. As the apical meristem is not protected as in the grasses, it is completely covered with the spray. Owing to the breadth and almost horizontal position of the foliage of nongraminaceous weeds, the film of the herbicide solution remains on it and thereby is allowed ample time to act on the tissues.

Treatment of the soil with 2, 4-D solution and its relation to the germination of weed seeds

On June 20, 1947, the nongraminaceous weeds on four 8-square-meter lots were uprooted with a trowel, care being taken to remove the entire root system. Three of the lots were treated with a 1,000 p.p.m. solution of 2, 4-D at the rate of 1.6 liters each. The control lot received no treatment. Four times, at intervals of 45 days, the same lots were sprayed with the same concentration of the herbicide and at the same rate.

In the last examination of the plots in December, 1947, it was observed that four repeated applications of 1,000 p.p.m. of 2, 4-D did not prevent the emergence of weed seedlings. It was noted, however, that there were less seedlings in the treated plot than in the untreated. The apparent ineffectiveness of 2, 4-D may have been due to the plots' being exposed and therefore

receiving wind-disseminated weed seeds during the experiment when there were frequent typhoons; or it may be due to the fact that, as Ahlgren and Cox (1946) noted, 2, 4-D is not poisonous, does not burn, and apparently leaves no residues in the soil which would act on the seedlings. Anderson and Wolf (1947) noted that annual grasses and broad-leafed weeds are effectively controlled by 2, 4-D for about six weeks.

In another experiment, a lot with only *Cyperus rotundus* Linn. on it was treated with a 20-per-cent 2, 4-D dust. All of the above-ground growths of the sedge were killed by the herbicide in a short period. For more than 30 days, the soil seemed to have been sterilized because not a single plant grew. After the first rains, however, the *Cyperus rotundus* and the other graminaceous weeds in the plot appeared. When the application of the 2, 4-D dust on the same lot was repeated, the weeds were readily killed and the plot remained free from weeds for about a month. The result showed that repeated application of 2, 4-D temporarily freed the plots from weeds.

The histological effects of 2, 4-D

The nongraminaceous weed used for the study of the effects upon the tissues of the 2, 4-D solution was *Amaranthus viridis* Linn., which was one of the species present in the vacant lots of the College of Agriculture where this work was conducted. The plants were in the flowering stage. Freehand cross sections of the stem were cut from the internode just below the flower stalk. The sections were killed and fixed in 95 per cent ethyl alcohol, stained with safranin, washed with water, passed through the ethyl alcohol series into the xylol, and mounted in balsam.

The tissues of *Amaranthus viridis* were rather slower in their response to the treatment with 1,000 p.p.m. 2, 4-D than those of the kidney bean as previously described by Swanson (1946), in whose study the first indication of histological activity was evident nine hours after the application of the herbicide. In the present study, however, it was noted that the activity was evident in about four days after the treatment.

The epidermis did not show any response to the treatment even up to the time that the plant was almost dead. The cortex being the most active tissue in *Amaranthus viridis*, the proliferation of the cells originating from the inner zone of the parenchyma of the cortex could be noticed in about a week after the treatment. These proliferated cells divided tangentially and radially and pushed themselves through to the outer zone of the collenchyma of the cortex. As this proliferation continued, the whole region of the cortex was almost replaced by the proliferated cells, which were not yet well differentiated. As a result of the continuous proliferation of the cells, cracks (fig. 2) appeared in the epidermis owing to the pressure exerted upon it from within. When cracks did not form because of the elasticity of the epidermal tissue,

enlargement and gall-like formations (fig. 1) appeared on the stems. Swanson (1946) called this cell proliferation root primordium, but according to his study, the root primordium was initiated by the ray cells immediately below the cortex. The endodermis of *Amaranthus viridis* did not show any marked activity due to the treatment with 2, 4-D. As a rule the layers of cambial cells between the phloem and xylem remained meristematic in both treated and untreated plants. In some cases slight activity of the cambial cells was noted in treated plants and this resulted in the merging of adjacent vascular bundles. The phloem parenchyma showed a marked activity, but the xylem parenchyma was only slightly active. The interfascicular cambium was never active in the tissues of the treated plants, or it was absent in both treated and untreated plants. The pith composed of parenchyma cells did not show any activity.

Swanson (1946) reported that root primordia are also formed in petioles of kidney beans that have been treated with 2, 4-D and then kept in a moist chamber after the treatment. The writers did not note any response of the petiole of *A. viridis* to 2, 4-D. This was probably due to the fact that the cortex, which is the seat of the cell proliferation, is not present in the petiole of *Amaranthus viridis*.

The flower stalk showed the same response to 2, 4-D as the stem.

SUMMARY

1. When the nongraminaceous species of weeds were sprayed with a 1,000 p.p.m. aqueous solution of 2, 4-D, the leaves took on a wilted appearance and yellowed and the stems bent and twisted. The death of susceptible species occurred in 6 to 20 days after the treatment, and resistant species fully recovered from the effects of the herbicide in 30 days.

2. A 100 p.p.m. solution of 2, 4-D is lethal to *Elephantopus spicatus* and *E. scaber* but the percentage of weeds killed is small. Concentrations of 2, 4-D higher than 1,000 p.p.m. but less than 2,000 p.p.m. give similar effects upon *Elephantopus spicatus* and *E. scaber* as a 1,000 p.p.m. solution. A brownish discoloration of the foliage appears when grasses are sprayed with 1,000 p.p.m. of 2, 4-D.

3. The following 49 species of weeds belonging to 17 families can be effectively controlled with a single application of 1,000 p.p.m. of 2, 4-D: *Asystasia gangetica* (Linn.) Anders., *Lepidagathis secunda* (Bl.) Nees, *Achyranthes aspera* Linn., *Aerua lanata* (Linn.) Juss, *Alternanthera ficoides*, *A. sessiles* (Linn.) R. Br., *Amaranthus spinosus* Linn., *A. viridis* Linn., *Celosia argentea* Linn., *Cyathula prostata* (Linn.) Bl., *Stachytarpheta jamaicensi* (Linn.) Vahl., *Heliothropum indicum* Linn., *Gynandropsis gynandra* (Linn.) Merr., *Commelina benghalensis* Linn., *C. nudiflora* Linn., *Hewittia sublobata* (Linn.) O. Kuntz, *Ipomoea cærica* (Linn.) Sweet, *I. pes-tigridis* Linn., *I. reptans* (Linn.) Poir, *Merremia hastata* (Desr.) Hallier f.,

M. gamella (Burm.) Hallier f., *M. vitifolia* (Burm. f.) Hallier f., *Ageratum conyzoides* Linn., *Blumea balsamifera* (Linn.) DC., *Cosmos caudatus* HBK., *Elephantopus spicatus* Aubl., *E. scaber* Linn., *E. mollis* HBK., *Emilia sonchifolia* (Linn.) DC., *Erigeron sumatrensis* Retz, *Synedrella nodiflora* (Linn.) Gaertn., *Vernonia cinerea* (Linn.) Less, *V. patula* (Ait.) Merr., *Cyperus rotundus* Linn., *Kyllinga monocephala* Rottb., *Acalypha indica* Linn., *Euphorbia hirta* Linn., *E. thymifolia* Burm., *Coleus blumei* Benth, *Hyptis suaveolens* Poir., *Eichornia azurea* Kunth, *Peperomia pellucida* HBK., *Portulaca oleracea* Linn., *Borreria hispida, Oldelandia corymbosa* Linn., *Pacderia tomentosa* Blume, *Scoparia dulcis* Linn., *Hydrocotyle asiatica* (Linn.) Urban., and *Pilea microphylla* (Linn.) Liebm.

4. The following nongraminaceous weeds, *Alysicarpus nummularifolius* (Linn.) DC., *Calopogonium muconoides* Desv., *Cassia mimosoides, C. occidentalis* Linn., *Desmodium capitatum* (Burm.) DC., *D. trifolium* (Linn.) DC., *D. scorpiurus* (Sw.) Desv., *Breynia cernua* (Poir) Muell-Arg., and *Oxalis repens* Thunb., are tolerant to 2, 4-D spray, probably owing to the inability of the spray material to stay on their leaves.

5. A 20-per-cent dust was effective for killing weeds with woody stems which are more than 1.5 meters tall.

6. The selective action of 2, 4-D spray on plants is probably at least partly attributable to morphological differences between the grasses and the broad-leafed weeds.

7. If applied on *Aeginetia indica* Linn. at the right stage of its development, a solution of 1,000 p.p.m. 2, 4-D controls the parasite. Spraying should be done just before or during the flowering stage so as to kill the entire plant and prevent its production of seeds for dissemination.

8. Four repeated applications of 2, 4-D on the soil in the open did not materially affect the appearance of weed seedlings.

9. The histological changes induced by 1,000 p.p.m. solution of 2, 4-D on the stem of *Amaranthus viridis* Linn. may be listed as follows:

Epidermis — No response.

Cortex — Very active; the cells of the inner zone of the parenchyma frequently divide tangentially and radially until the whole cortex is replaced by the proliferated cells.

Endodermis — Very slight activity; the cells, however, divide frequently.

Phloem parenchyma — Very active.

Xylem parenchyma — Slightly active.

Cambial cells — Remain meristematic.

Ray cells — Very slight activity.

Pith — No response.

10. The flower stalk of *A. viridis* responded like the stem to 2, 4-D. The petiole, however, did not show marked changes.

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TABLE 1

The effect of varying the concentration of 2, 4-D in the January to March, 1947, application on the percentage of Elephantopus scaber and E. spicatus killed

CONCENTRATION	ELEPHANTOPUS SCABER					ELEPHANTOPUS SPICATUS				
	Average height[a]	Average diameter[b]	Original count January 10	Final count March 10	Per cent killed	Average height[a]	Average diameter[b]	Original count January 10	Final count March 10	Per cent killed
	cm.	*cm.*				*cm.*	*cm.*			
Control	45	.9	21	29	—	30	.6	49	60	—
2,000 p.p.m.	50	1.0	27	0	100.0	30	.5	52	0	100.0
1,500 " " "	50	1.0	24	0	100.0	30	.5	32	0	100.0
1,000 " " "	47	1.0	26	0	100.0	31	.5	61	0	100.0
500 " " "	49	1.0	30	2	93.3	30	.4	25	15	40.0
200 " " "	48	.9	19	7	63.1	27	.3	20	17	65.0
100 " " "	47	.9	23	18	27.2	26	.3	22	19	15.0

[a] Measured from tip of flowering stalk to base of plant.

[b] Measured at the base of the plant.

TABLE 2

The effect of varying the concentration of 2, 4-D in the October to December, 1947, application on the percentage of Elephantopus scaber and E. spicatus killed

CONCENTRATION	ELEPHANTOPUS SCABER					ELEPHANTOPUS SPICATUS				
	Average height[a]	Average diameter[b]	Original count October 12	Final count December 22	Per cent killed	Average height[a]	Average diameter[b]	Original count October 12	Final count December 22	Per cent killed
	cm.	*cm.*				*cm.*	*cm.*			
Control	15	.9	41	52	—	26	.2	38	49	—
2,000 p.p.m.	17	.8	58	0	100.0	28	.2	32	0	100.0
1,500 " " "	18	.8	49	0	100.0	25	.2	37	0	100.0
1,000 " " "	14	.7	24	0	100.0	27	.2	55	0	100.0
500 " " "	15	.9	37	3	91.8	26	.2	46	13	71.7
200 " " "	15	.8	57	24	57.4	25	.2	27	14	48.1
100 " " "	15	.8	58	40	31.03	25	.2	43	35	10.8

[a] Measured from tip of flowering stalk to base of plant.

[b] Measured at the base of the plant.

EFFECTS OF PHOTOPERIOD UPON THE UPLAND RICE PLANT VARIETY ININTIW[1]

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WITH ONE TEXT FIGURE

Although the amount of published work on light and its influence on plant growth is enormous, studies of this nature in the Philippines are very limited. Even studies on the effect of light on rice, the most important crop plant in this country, have hardly been made. Because of this fact, it is of interest to study the comparative effects of varying lengths of photoperiod on upland rice. It is suspected that the length of illumination which the plant receives from the sun in the Philippines might be a cause of its low yield. This study was, therefore, made in the hope that it might throw some light on the subject. The work was carried out in pot cultures. The first two sets were conducted in the experimental lot of the Department of Agricultural Botany of the College of Agriculture at Los Baños, Laguna, from December, 1945, to March, 1947; the third set, because of limited lighting facilities, was conducted in the nearby barrio of San Antonio, Los Baños. In making any comparison of the data obtained as influenced by varying the period of illumination, the length of daylight at the College was used as the basis.

Review of literature

Comparative culture studies reveal that the length of photoperiod has a marked influence on the growth, development, and reproduction of most plants. From such studies, it was found possible to classify flowering plants into short-day plants, long-day plants, and short- and/or long-day plants (Garner and Allard, 1920).

Muntz (1913) observed that alfalfa produced a larger yield of green material per square meter during the summer of 1910, when rain was frequent and cloudy skies prevailed, than in 1911, when the sky was unusually free of clouds. His findings in the laboratory seem to confirm his observations in the field. On the other hand, Combes (1910) reported that in general, strong light induced the development of the storage organs of plants, whereas diffused light tended to decrease the amount of food in such

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organs as leaves and herbaceous stems. Espino and Pantaleon (1930) also observed that direct sunlight was far more effective than diffused light in promoting the growth and development of five species of plants, including rice and corn.

Lubimenko (1910) found that light was absolutely necessary in initiating the development of the fruit. He observed that the development was able to proceed in darkness with corresponding reduction in dry matter only after the embryo had started to develop after fertilization. Lauritzen, Brandes, and Matz (1946) also found that, in general, the development of sugar-cane plants improved with increased light intensity in each of the temperatures studied. They believed that for every temperature occurring within the normal range of this factor, a definite amount or quota of light is required for maximum growth.

Yap (1920) reported that photosynthesis in the sugar-cane plant was more active in the morning than in the afternoon, being most active from 8:00 a. m. to 10:00 a. m. and decreasing from 10:00 a. m. to 4:00 p. m. Espino and Pantaleon (1930) also reported that to five species of higher plants among which were corn and rice, the morning sunlight was more beneficial than the afternoon sunlight.

That most plants could be grown under artificial light was amply demonstrated by Arthur (1929). Maximov (1938) added that the greatest difficulty in growing plants in artificial light was not in providing sufficient intensity but in securing light of the quality which would permit normal photosynthesis. He observed that most plants required, on the average, about 500 watts per square meter of soil surface. On the other hand, Shirley (1929) reported that the light intensity needed for the survival of plants, like buckwheat, wandering Jew, hog peanut, and tomato was very low, being less than 40 foot-candles for all, except for the sunflower, which required a much higher intensity. He noted that the percentage of dry matter in tops, the ratio of dry weight of roots to dry weight of shoots, and the density of growth increased with increased light intensity. Moreover, he noticed that the time of maximum flowering and fruiting was considerably delayed by low light intensities.

Zimmerman and Hitchcock (1929) reported that dahlia flowered readily when exposed to a photoperiod of 7 to 9 hours a day. They observed that the plants that were subjected to long days produced many fibrous roots, whereas those that were exposed to a shorter period of illumination produced heavier storage roots.

Working on photoperiodic influence on rice plants in the field, Beachell (1943) reported that, in general, the varieties that were subjected to a daily 10-hour photoperiod usually headed earlier than the control.

Greenhouse studies conducted by Evans and Wilsie (1946) showed that the 18-hour day seemed to be favorable to the flowering of bromegrass, *Bromus inermis*, but no flowering occurred under normal-day length (9 to 10 hours), and only some flowering occurred in a 15-hour day.

MATERIALS AND METHODS

Plants. Sufficient seeds of an upland rice, variety Inintiw, were secured from the Department of Agronomy. They were soaked in water for forty-eight hours and directly planted as follows: in the first set, seven seeds in each big iron drum used as culture pot; in the second and third sets, five seeds in each gallon tin pot. When about five centimeters tall the young plants were thinned. Four uniformly developed seedlings were left in each pot in the first set, and one plant in each pot in the second and third sets.

Culture media. Lipa clay loam soil was employed as the solid medium in all the cultures. It was pulverized and thoroughly mixed before it was used. Air-dry horse manure was added to the soil to improve its fertility and water-holding capacity.

Photoperiod chambers. Five dark chambers were made for the photoperiod study in the first set of cultures. The frame of each chamber was made of wood and of the shape of a box 183 cm. long, 61 cm. wide, and 152 cm. high. This frame was covered with black-dyed gunny sack of extra thickness. The gunny-sack covers were not permanently attached to the frame but could be removed whenever not needed. Two of these chambers were used in the second set and one chamber in the third set with a lighting device. Two 200-watt Mazda lamps were attached to ordinary sockets and provided with a homemade lampshade of thick cardboard. In the photoperiod chamber this device was suspended over the pot cultures about 30 centimeters from the plants. To avoid overheating the plants, the electric bulbs were raised higher as the plants grew taller. According to Maximov (1929) and Shirley (1929), two such electric bulbs can furnish most plants with light of sufficient intensity.

Photoperiod cultures. Of the three sets of photoperiod cultures, which were run one after the other, the plants in the first set of six cultures were exposed to sunlight as follows:

Culture I, from sunrise to 1:00 p.m.
Culture II, from sunrise to 2:00 p.m.
Culture III, from sunrise to 3:00 p.m.
Culture IV, from sunrise to 4:00 p.m.
Culture V, from sunrise to 5:00 p.m.
Culture VI, from sunrise to sunset.

Each of cultures I to VI, inclusive, was run in triplicate. The three pots were placed in a row in a chamber so that the plants were continuously

exposed to sunlight till the indicated time in the afternoon. To vary the period of illumination, the gunny-sack covers were placed over the frames of the chambers at one-hour intervals, thus: at 1:00 o'clock in culture I, at 2:00 o'clock in culture II, etc. The plants in culture VI were exposed to sunlight throughout the day; that is, from sunrise to sunset. At nightfall the covers of all the chambers were removed.

In the second set of cultures, six plants (one plant to each pot) were used for each period of exposure to light. Since the pots used in this set were smaller, the potted plants of the cultures could be moved easily from the dark chambers to the sunlight and vice versa. The plants were exposed to the same periods of illumination used in the first set of cultures. In the second set of cultures, the plants were subjected to a different length of exposure to sunlight; that is, they were exposed to the light only from noon till sunset. The plants were kept in the dark chamber from sunrise till noon of the same day.

In the third set of cultures, four plants (one in each pot) were used. The plants in culture I received sunlight throughout the day, from sunrise to sunset. The plants in culture II were exposed to sunlight for the same period of time and in addition were given illumination by electric light from the two 200-watt Mazda lamps from sunset till eight o'clock in the evening.

EXPERIMENTS, RESULTS, AND DISCUSSION

The first set. The first set of cultures was run from June 5, 1946, to October 9, 1946. The soaked seeds of Inintiw rice were planted in the culture pots on June 8. The required number of seedlings were subjected to the different photoperiod treatments beginning June 18, and the mature plants were harvested on October 9, 1946.

The second set. The seeds for the second set of cultures were planted on October 5, 1946. The young rice plants were given the photoperiod treatment beginning October 13, 1946. The plants were harvested on January 28, 1947.

The third set. The seeds for this set of cultures were planted in the pots on October 2, the photoperiod treatments began on October 13, 1946, and the plants were harvested on February 12, 1947. It was in this set that the photoperiod was lengthened with the use of electric lights. Figure 1 is a photograph of the cultures on December 11, 1946, or eight weeks after the treatment.

The plants in each set were given, as much as possible, the same amount of soil and the same care and treatment in regard to watering, weeding, cultivation of soil in the pots, drainage, and control of diseases and pests.

Fig. 1.—Inintiw rice plants two months after treatment. Plants 1-4 were exposed to ordinary length of daylight + additional light from sunset to 8:00 p. m. with the use of artificial light; and 5-8 to ordinary length of daylight only. (*Photographed by Ricardo Laforteza*).

Weather data

The sunrise and sunset hours in Manila were furnished by the director of the Philippine Weather Bureau. They show marked variation in the hours of sunrise and sunset; consequently, the lengths of the periods of illumination during this study gradually decreased each month from June to December, 1946, for the city of Manila. Owing to the proximity of Manila to Los Baños where the present study was conducted, the average data for Manila shown below were used.

MONTH	SUNRISE HOUR	SUNSET HOUR	LENGTH OF DAYLIGHT	
1946	*a.m.*	*p.m.*	*hrs.*	*min.*
June	5:27	6:25	12	56
July	5:35	6:28	12	53
August	5:42	6:18	12	36
September	5:45	5:58	12	13
October	5:47	5:35	11	48
November	5:57	5:25	11	28
December	6:13	5:46	11	33

The rainfall, temperature, and number of rainy days in the College of Agriculture, Los Baños, Laguna, observed for the months of June, 1946, to January, 1947, inclusive were as follows: The monthly rainfall gradually increased from June, and reached its peak of 403.8 mm. in September, 1946. It decreased towards December, and in January, 1947, the rainfall was only 26.0 mm. Observations showed also that from June, 1946, to January,

1947, 48 per cent of the rainy period occurred during the afternoon between midday and 6:00 p. m., 26 per cent during the morning hours from 6:00 a.m. to 12:00 noon, and the remaining 26 per cent during the night. The fluctuations in mean temperatures were slight, ranging from 26.7°C. in the months of June and August to 25.1°C. in the month of November, 1946.

Owing to the inadequate experimental facilities and equipment available at the time the study was conducted, the temperature and the humidity in the dark or in the photoperiod chambers were neither determined nor controlled. Neither were the light intensities determined. The discussion of the results obtained is, therefore, limited to the effects of the lengths of the photoperiod upon the vegetative development, flowering, and fruiting of the upland rice variety Inintiw.

Effects of photoperiod [2]

On production of leaves. The maximum production of leaves in cultures II to VI, inclusive, took place the third week after the start of the photoperiod treatment. On the other hand, similar experimental data in cultures III to VI, inclusive, seemed to show that the maximum weekly production of leaves in the second set of cultures occurred one week later; that is, during the fourth week. This one week difference in the two sets of cultures, however, was more apparent than real because the photoperiod treatments were started with slightly older rice plants in the first set. The highest weekly production of leaves in these two sets of cultures occurred when the rice plants were about one month old from the time of planting. In culture I of the first set, however, and in cultures I and II of the second set, the maximum weekly production of leaves took place later. Thus, it appears that a decrease in the period of exposure to sunlight delayed the production of the maximum number of leaves of the plant.

Even the production of the total number of leaves seems to have been influenced by the length of photoperiod. Except for the little discrepancy in culture V the production of leaves of the rice plants decreased with corresponding reductions in the period of sunlight illumination. Lengthening or shortening the period of exposure of the plants to light, especially in culture VII, produced divergent effects upon the plants—production of more leaves when the period of illumination was artificially prolonged, and production of less leaves when shortened. This was especially so when the morning sunlight was cut off, making only the afternoon sunlight available to the plants.

The difference in number of leaves between any two of the cultures from II to V, inclusive, was insignificant. The least average number of leaves per plant was produced in culture I, the highest in culture VI.

[2] The experimental data obtained from the first and second sets of cultures are on file in the Department of Agricultural Botany.

Incidentally, when the comparison was made in number of leaves between the latter and any of the other cultures, the difference in favor of culture VI was significant.

Now, when the data on the number of leaves produced by the individual plants were likewise statistically treated, almost similar results were obtained. The number of leaves from culture VI was the highest. The difference between this number and any of the others obtained from the cultures in which the period of illumination was artificially shortened (cultures I to V, and VII) was significant. The number of leaves produced decreased considerably when the period of exposure of the rice plants to ordinary daylight was shortened by one to five hours.

On the other hand, when the period of illumination from sunlight was artificially lengthened by using electric light of sufficient intensity from sunset to eight o'clock in the evening, the average number of leaves per plant was increased by 50 per cent over that produced by the plant that received ordinary daylight from sunrise to sunset. In the production of leaves, therefore, a day longer than the ordinary will be more beneficial to Inintiw (table 1).

On tillering. The maximum weekly increase of tillers took place one month from the time of planting. The total number of tillers was highest in culture VI; however, when the period of illumination was cut shorter by about one hour to five hours, the total number of tillers, as shown in cultures I to V inclusive, decreased rather considerably. Therefore, the period of illumination from the sun had a direct influence on tiller production; that is, the longer the exposure, the more tillers were produced.

This finding is further substantiated by the fact that culture II produced 66.6 per cent more tillers than culture I. Therefore, as in the production of leaves, a longer period of illumination was conducive to more active tillering; and, if ordinary daylight can be lengthened, surely more tillers will be produced by the Inintiw rice plant. As in the case of the leaves of this plant, tiller production was adversely influenced by the afternoon sunlight.

When the number of tillers produced by the rice plants in the first and in the second sets was subjected to the analysis of variance, culture II and culture VI were found to be the best. The plants in these two cultures received the maximum light duration from the sun, from sunrise to sunset. When these two cultures were compared with cultures I to V, inclusive, in the two sets of cultures, their differences were found to be significant. When, however, the first five cultures of the first set and cultures II to V of

the second set were compared in regard to number of tillers, the differences were found insignificant. Therefore, it appears that a day shorter than the ordinary would be detrimental to the production of tillers of Inintiw.

On the other hand, culture II produced 66.6 per cent more tillers than culture I. Culture II received about two hours of electric light more than culture I. In other words, the rice plants that received light from sunrise to sunset and additional illumination from electric light from sunset to eight o'clock in the evening produced more tillers than those that received sunlight only from sunrise to sunset (table 1). Were it possible to have a longer day or to lengthen artificially the period of illumination experienced during the course of this study, more tillers would be produced by Inintiw.

On emergence of panicles. In culture VI the plants required an average of 89.5 days from planting to the appearance of the first panicles. This number is the highest recorded and its difference from any of the other figures obtained in cultures I to V, inclusive, was statistically significant. The plants in this culture received the longest period of illumination from the sun. It stands to reason, therefore, that shortening the period of exposure to sunlight induced the plants to produce panicles earlier, a fact which is probably desired in practical farming. The time of emergence of panicles was, however, not directly proportional to the length of exposure to sunlight.

When the period of exposure to sunlight was greatly shortened, or the plants were exposed only to the afternoon light, the appearance of panicles was markedly delayed. When the effects on the emergence of panicle by the sunrise-to-sunset illumination in culture VI were compared with those in any of the cultures from I to V, inclusive, the difference was significant, except in culture II. Thus, as a whole an exposure to light shorter than the ordinary length of the day hastened the emergence of panicles of this rice variety. As in the first set of cultures, however, the figures for cultures I to V, inclusive, show a lack of correspondence between the shortened periods of illumination and the first emergence of panicles.

By artificially lengthening the daylight period with the use of electric light from sunset to eight o'clock in the evening, the production of panicles was further markedly delayed. In culture II (table 2) the first panicles appeared 109.5 days (average) from the time of planting; this was 100 per cent longer than was required by the plants in culture I to produce the first panicles. Therefore, a longer illumination beyond the ordinary day was conducive to a prolonged vegetative development and resulted in delayed appearance of panicles.

On maturity of grains. The number of days from emergence of panicles to maturity of grains ranged, on the average, from 26.3 to 28.1 days. Sim-

ilarly, emergence of panicles to maturity of grains, ranged from 24.5 days in culture II to 31.6 days in culture VII, and 25.5 days in cultures III and VI. In culture VII, in which the plants were exposed to the afternoon sunlight only, grains matured the latest. When the data for cultures I to VI, inclusive, were compared with one another, no significant differences were noted; however, when the data for culture VII were each compared with those of cultures I to VI, the differences were significant. Moreover, culture I required, on the average, 28.3 days from emergence to maturity of grains, whereas culture II took only 23.3 days.

From the foregoing discussion, it becomes apparent that the maturity of the grains of Initiw was neither hastened nor retarded when the period of exposure of the plants to sunlight was made shorter than the length of the ordinary day in Los Baños. The maturity of grains under the afternoon sunlight was, however, markedly delayed; but by artificially lengthening the period of illumination from 12 to 14 hours, the rate of maturity of the grains became faster, being on the average five days shorter, or a difference of 21.4 per cent (table 2).

On yield of grain. The yield of grain in culture VI was highest, but when compared with the yields of any of the cultures from II to V, inclusive, the difference was found to be insignificant. A significant difference was, nevertheless, noted when it was compared with culture I. It appears, therefore, that unless the period of exposure of the plants to sunlight becomes much shorter by at least five hours than the ordinary length of daylight, the yield of grain is not adversely affected seriously. This generalization is not fully confirmed by the results obtained from the second set of cultures, for when the data in culture VI were compared with those of culture I, the difference was not significant.

It should be noted, however, that the yield of grain from culture VII was decidedly low in comparison with the yields from the other cultures. Since the plants in this culture received only the afternoon sunlight, it may be concluded that the afternoon sunlight was not conducive to a higher yield of grain.

It should further be noted that culture I gave a yield of 3.7 grams of rice grains. This culture received the ordinary length of daylight. When the period of illumination was lengthened with the use of electric light from sunset to eight o'clock in the evening, the yield became 9.7 grams (table 2). The increase was 162 per cent. Therefore, extending the length of photoperiod from 12 to 14 hours proved to be beneficial to the Inintiw rice plants.

On the yield of roots. The yield of roots from culture VI was almost the same as that from any of the cultures II, III, IV, and V. The difference between VI and any one of the four cultures is less than the L. S. M. D.

of 4.46. Culture I produced an average of 6.1 grams of roots, which was significantly lower than the root yield from II, III, IV, V, or VI. The marked decreases in the yield of roots were noted as the period of exposure to light was made shorter than the length of natural illumination from sunrise to sunset. Culture VI gave the highest yield of roots, which was significantly higher than any other yield obtained from the rest of the cultures in the set. A discrepancy, therefore, became apparent between yield of roots in the first set and that of the second set of cultures; but, on the whole, the yields in the two sets of cultures showed a similar tendency to decrease with the reduction in the period of illumination. It should be noted that when the length of photoperiod was extended to eight o'clock in the evening, the yield of root was increased by about 944 per cent (table 2).

On the yield of tops. In cultures II to VI, inclusive, the yields of tops of the rice plants in the first set were similar. When considered on the basis of L. S. M. D., which was 7.58, not any two of them showed a significant difference. Culture I, however, gave significantly the lowest yield of tops. From these results, it may be inferred that the reduction of the period of illumination, provided it was not very excessive, adversely affected the growth and development of tops of Inintiw.

The data on the yield of tops from the second set of cultures showed slightly different results. Cultures V and VI gave the highest yields of tops, and the difference between them was insignificant. The next two highest figures were obtained from cultures III and IV, but the difference between them was insignificant. The two lowest yields came from cultures I and II; again the difference between them was insignificant. In these cultures, therefore, the yield of tops gradually decreased with the reduction in the period of illumination from sunlight. Moreover, when the markedly shortened photoperiod illumination was obtained from the afternoon sunlight, the decrease in the yield of tops was radical.

On the other hand, when the period of illumination was lengthened by switching on the electric light after sunset till eight o'clock in the evening, the yield of tops was greatly increased (table 2). Culture II gave a yield of tops 144.2 per cent greater than culture I.

It appears, therefore, that although the exact nature of the effects of the lengths of light upon the growth and development of tops of rice plants was not clearly established, it was quite evident that artificially lengthening the ordinary period of illumination from sunlight greatly increased the yield of tops.

With the data thus far considered piecemeal, it might be of interest to look at the rice plant as it reacts to varying periods of illumination.

Although the roots of the rice plants were buried in the ground and therefore not exposed to light, the development of the roots was markedly

influenced by the period of illumination. It was established that a decrease in the length of illumination brought about a corresponding decrease in the yield of roots and, an increase in the period of illumination produced an increase in the amount of roots. A most radical decrease in the yield of roots was obtained when the rice plant was exposed only to the afternoon sunlight. This adverse effect of the afternoon light corroborate Espino and Pantaleon's (1930) findings.

The development of tops was also affected by the period of illumination. As the period of sun illumination was decreased, hardly any adverse effect upon the tops was noted, or if there was any at all, it was rather a moderate or gradual decrease in yield with the decrease in light duration. Moreover, the afternoon light caused a marked decrease in the yield of tops, corroborating again Espino and Pantaleon's (1930) findings; however, as the period of illumination was lengthened beyond the ordinary daylight period, the amount of tops produced was greatly increased.

The production of leaves was likewise affected by the period of illumination. In general, a shortened light period not only delayed the maximum weekly production of leaves but also decreased the number. On the other hand, artificially lengthening the period of illumination brought about an increase in the number of leaves.

The period of illumination seemed to have a consistent effect on tillering. The production of tillers decreased as the length of sunlight was shortened; a decrease in photoperiod caused a delay in tillering; and the afternoon sunlight markedly decreased tillering. On the other hand, the production of tillers increased when illumination was lengthened to 14 hours.

The time for emergence of panicles was apparently not determined by the length of illumination when received only from the sun. Both the afternoon sunlight and the artificially prolonged period of illumination caused a delay in panicle emergence.

The causes for the delay in the two cases were probably not the same. In the case of the afternoon light, the delay in the appearance of panicles was probably due to insufficient photosynthesis. Espino and Pantaleon (1930) observed that rice plants produced less dry matter when exposed to the afternoon sunlight than when exposed to the morning light. It was suspected that the decrease in photosynthesis was due to rapid transpiration in the afternoon, resulting in the closing of the stomatal pores and thus preventing the intake of carbon dioxide, which is esssential to photosynthesis. Another probable cause of the delay in flowering was a carbon-nitrogen ratio in the leaves far below unity. This ratio was probably produced following the decrease in photosynthesis but with a continuous intake of nutrients from the soil. Espino and Crocker (1940) reported that such a carbon-nitrogen ratio was not quite conducive to early flowering of the rice plants.

In the case of the artificially prolonged period of illumination, the delay in panicle emergence was probably due to a certain photoperiodic requirement of the plant. Maximov (1938) stated that when exposed to a long-day photoperiod, some short-day plants, like rice, continued to vegetate, accompanied by a pronounced delay in flowering. Such behavior of the rice plant was observed in this study. Flowering was also somewhat delayed when the plants were exposed to sunlight from sunrise to sunset. Of course, the delay in flowering was not so much when the plants were exposed to the afternoon sunlight, and it may be attributed to the fact that during the morning exposure, the plants were able to produce some organic food because of which food the carbon-nitrogen ratio in the leaves became closer to unity and probably counterbalanced the delaying effect in panicle emergence of the afternoon sunlight. Thus, the delay in the appearance of panicle in the sunrise-to-sunset exposure was not so much as when the exposure was to the afternoon sun alone. Beachell (1943) attributed late flowering or the failure of varieties from the tropics to flower to longer days and cooler weather when grown in the southern states. The same author was able to hasten the flowering of 10 varieties of rice plants by subjecting them to a daily 10-hour photoperiod.

The maturity of the grains was neither consistently hastened nor retarded when the plants were exposed to daylight periods of varying lengths. The afternoon sun, however, retarded the maturity of grains. By artificially lengthening the period of illumination, an earlier maturity of grains was obtained. A decrease in the length of daylight did not materially decrease the yield of grain except when the decrease amounted to at least five hours each day. A higher yield of grain was obtained when the period of illumination was lengthened artificially with the use of electric light.

From the foregoing discussion, it becomes evident that inadequate light duration is, at least, one of the causes of the normal low yield of rice in the Philippines and that the present yield of grain of Inintiw when grown under Los Baños conditions can be increased. It has been shown that the increase of yield amounted to as much as 162 per cent just by lengthening ordinary daylight with two hours of electric light.

SUMMARY

1. A decrease in the length of illumination brought about a corresponding decrease in the yield of roots and in the production of leaves and tillers of the rice plant variety Inintiw. Hardly any adverse effect upon the amount of top was noted.

2. Extending the period of illumination with the use of artificial light produced an increase in roots and tops. The number of leaves and tillers was also increased.

3. The time for emergence of panicles was not affected by the length of illumination when received only from sunlight. Both afternoon sunlight and the artificially prolonged period of illumination caused a marked delay in panicle emergence.

4. Exposure to daylight periods of varying lengths neither consistently hastened nor retarded the maturity of the grains. An earlier maturity of grains was obtained by extending the photoperiod with the aid of artificial illumination. The grains that were exposed to the afternoon sunlight only matured latest.

5. A decrease of less than five hours a day in the length of daylight did not materially decrease the yield of grain. A higher yield of grain was obtained when the period of illumination was lengthened artificially to eight o'clock in the evening.

6. Inadequate light duration is possibly one of the causes of the low yield of rice in the Philippines.

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TABLE 1

Experimental data on weekly and total production of leaves and tillers of rice plants exposed to two different lengths of illumination

WEEKLY INCREASE AND TOTAL NUMBER OF LEAVES

CULTURE NO.	PHOTOPERIOD	OCT. 13 TO OCT. 20	OCT. 20 TO OCT. 27	OCT. 27 TO NOV. 3	NOV. 3 TO NOV. 10	NOV. 10 TO NOV. 17	TOTAL
I	Daylight	3.60	3.65	3.25	5.75	3.25	91
II	Daylight plus electric light to 8:00 p.m.	2.50	3.75	3.75	8.50	12.74	137

WEEKLY INCREASE AND TOTAL NUMBER OF TILLERS

I	Daylight	0.75	0.75	0.25	1.50	1.25	18
II	Daylight plus electric light to 8:00 p.m.	0.25	1.00	0.25	3.00	2.75	30

TABLE 2

Experimental data obtained from the third set of cultures on production of leaves, roots, tillers, panicles, and rice grains

CULTURE NO.	PHOTOPERIOD	PLANT NUMBER 1	2	3	4	TOTAL	AVERAGE
NUMBER OF LEAVES							
I	*a*	15	24	25	27	91	22.8
II	*b*	36	37	34	30	137	34.3
NUMBER OF TILLERS							
I	*a*	2	5	5	6	18	4.5
II	*b*	8	9	7	6	30	7.5
NUMBER OF DAYS FROM PLANTING TO FIRST EMERGENCE OF PANICLES							
I	*a*	59	53	52	54	218	54.5
II	*b*	109	110	110	109	438	109.5
NUMBER OF DAYS FROM FIRST EMERGENCE OF PANICLES TO MATURITY OF GRAINS							
I	*a*	29	29	27	28	113	28.3
II	*b*	23	23	23	24	93	23.3
AIR-DRY WEIGHTS OF GRAINS							
I	*a*	2.7	5.1	3.4	3.7	14.9	3.7
II	*b*	10.3	12.5	11.1	7.0	38.9	9.7
AIR-DRY WEIGHTS OF ROOTS							
I	*a*	0.4	1.2	1.0	1.1	3.7	0.9
II	*b*	9.2	10.3	10.2	7.9	37.6	9.4
AIR-DRY WEIGHTS OF TOPS							
I	*a*	2.0	7.3	5.8	6.0	21.1	5.2
II	*b*	13.5	13.5	11.7	10.2	50.9	12.7

[a] Ordinary length of daylight

[b] Ordinary length of daylight plus electric light from sunset to 8:00 p.m.

THE GROWTH AND DEVELOPMENT OF PHILIPPINE AND MURRAH CARABAOS AND THEIR CROSSBREED[1]

FIDEL F. REYES

The carabao plays an important rôle in Philippine agriculture. It furnishes the power unit on farms with areas from less than a hectare to five hectares, which constitute 96.3 per cent of the farms in the Philippines, and even on larger farms it is useful for work where the topography of the land makes animal labor more advantageous than the use of machinery. Its milk possesses a high nutritional value, and a limited number of carabaos are slaughtered for meat.

The Murrah carabao was introduced into the Philippines for dairy purposes. According to Sarao[2] the average annual milk production of Philippine carabaos is 255.05 liters; Murrah carabaos, 325.69 liters; and their crossbreeds, 495.26 liters. Murrah carabaos are known in the Philippines for their large size and hardiness.

The relative increases in weight and measurements of the different parts of the body of Philippine carabaos, Murrah carabaos, and Murrah-Philippine carabao crossbreeds were studied in the Department of Animal Husbandry of the College of Agriculture, Los Baños, Laguna, first by Sotero Lantican[3] from June 22, 1923, to December 31, 1925, continued by Ceferino Villanueva[4] to January 7, 1927, extended by José M. Villegas[5] to March 9, 1929, by José F. Luna[6] to January 2, 1931, and by the writer from October 31, 1932, to December, 1933. The present paper

[1] Experiment Station Contribution No. 1485. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. 1934. Prepared in the Department of Animal Husbandry under the direction of Professor Valente Villegas.

[2] SARAO, F. B. 1929. The cost of producing milk at the College of Agriculture. Philippine Agriculturist **18**: 427–438.

[3] LANTICAN, S. P. A preliminary study of growth and development of Philippine, Murrah, and crossbred water buffaloes. I. (Thesis presented for graduation with the degree of Bachelor of Agriculture from the College of Agriculture. 1926. Unpublished).

[4] VILLANUEVA, C. J. A preliminary study of the growth and development of Philippine, Murrah, and crossbred water buffaloes. II. (Thesis presented for graduation with the degree of Bachelor of Agriculture from the College of Agriculture. 1927. Unpublished).

[5] VILLEGAS, J. M. A preliminary study of the growth and development of Philippine, Murrah, and crossbred water buffaloes. III. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. 1931. Unpublished).

[6] LUNA, J. F. A preliminary study of the growth and development of Philippine, Murrah, and crossbred water buffaloes. IV. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. 1932. Unpublished).

includes results of the mentioned workers and data from the records of the Department of Animal Husbandry from January 31, 1931, to October 1, 1932. The total time covered by the results presented in this paper is ten years and a half.

ANIMALS USED

Seventy-five animals were used in the investigation of which 26 (12 males and 14 females) were of Philippine blood, 30 (19 males and 11 females) Murrah carabaos, and 19 (9 males and 10 females) Murrah-Philippine carabao crossbreeds. Philippine and Indo-Chinese bulls, both of which belong to the same breed, were employed for producing the Philippine carabaos used in this work.

WEIGHING THE ANIMALS AND MEASURING THE DIFFERENT PARTS OF THEIR BODIES

The animals were weighed on a livestock scale of the pit type and the different parts of the body were measured with a wooden caliper and a steel tape graduated in metric units. The weights and the measurements were taken in the morning of the day the animals were brought in for study. In weighing and measuring, care was taken that the animal stood squarely on four legs on a level floor. Animals under six months of age were weighed and measured every two weeks, and older ones every month.

DISCUSSION OF RESULTS

The weight, height at withers, heart girth, and circumference of barrel are discussed more fully than the length and width of the head, length and circumference of the horns, width and depth of the chest, length of the back and of the rump, width of the loin, and lengths of forearm, foreshank, and front hoof. Of the measurements taken of the other parts of the body, only increases are considered.

Weight at birth

The averages of weights at birth of the males of the Philippine and Murrah carabaos and their crossbreeds showed that the crossbreeds were the heaviest, the Murrahs second, and the Philippine animals third. With females, Murrah carabaos were the heaviest at birth, the crossbreds next, and the Philippine carabaos the lighest.

When the weights at birth of the males and females of the same blood composition were compared, it was noted that the male crossbreeds were heavier than the females. In the case of the Philippine and Murrah carabaos, however, the females were heavier than the males at birth.

Increase in body weight

Males. The crossbreeds were the heaviest from birth up to the third month, the Murrahs second, and the Philippine carabaos third. In the

fourth month, the Murrahs equalled the crossbreeds in weight and the Philippine carabaos ranked second. From the fifth month to the ninth month, the weight of the Murrahs led, the crossbreeds second, and the Philippine carabaos third. From the ninth month to the third year, the crossbreeds weighed much more than the Murrahs whereas the Philippine carabaos remained third although they had the same rate of growth as the Murrahs.

The percentage of increase of body weights of the Murrah carabaos and the crossbreeds over the Philippine carabaos at two years was 56.2 per cent. In the fourth year, the Murrah carabaos were at their best; they were 28.37 per cent heavier than the Philippine carabaos.

A drop in the rate of increase of the body weight of the Murrah carabaos was noted in the 30th month, whereas the Philippine carabaos were second to the crossbreeds in rate of increase. In the 33rd and 36th months the Murrah carabaos again rose to second place with the Philippine carabaos a close third. From the 48th to the 54th months the Murrah carabaos were leading in weight increase, the crossbreeds second, and the Philippine carabaos third. It was also noted that from birth to maturity the weight of the Philippine carabaos and of the crossbreeds continually though gradually increased, whereas that of the Murrah's remained unchanged from the 60th to the 66th month. The crossbreeds were the heaviest during the fifth year, the Murrah carabaos second, and the Philippine carabaos third.

Females. As regards the female carabaos, Murrahs were on the average the heaviest, and the crossbreeds were heavier than the Philippine carabaos. From the age of 12 to 33 months the crossbreeds outweighed the Murrahs, but from thereon to maturity, the Murrahs outweighed the crossbreeds. The Philippine carabaos weighed the least throughout, except in the 78th month when they were second to the Murrah carabaos, and the crossbreeds third.

Height at the withers at birth

The male Philippine × Murrah crossbreeds had the highest height at the withers at birth, the average being 73.92 cm. The Philippine carabaos were 0.2 cm. shorter than the crosses and the Murrah carabaos 0.16 cm. shorter than the Philippine.

Females. The females of the Philippine carabaos and of the crossbreeds were almost of the same height at birth, and the Murrah carabaos were the lowest.

Measurements of the height at the withers of the males at birth compared with those of the females of the same breed showed that the males of the Philippine breed and of the crossbreeds were a little taller than the females of the same breed. The males of the Murrahs were 3.64 cm. taller than the females.

Increase in height at the withers

Males. From the first month to the end of the 36th month the crossbreeds ranked first in increase in height, and the Murrah carabaos second up to the 27th month. The Philippine carabaos replaced the Murrah carabaos in second place in the 30th and 33rd months, the Murrah carabaos being then 2.15 per cent lower than the Philippine breed. From the 36th to the 60th month, the crossbreeds were slightly taller than the Murrahs. During the first six months the increase in height of the Philippine carabaos was almost the same as that of the Murrahs, the increase keeping pace with the growth of the crossbreeds and Murrahs. The latter began to grow faster than the others at the age of 12 months and maintained this rate up to maturity. The Philippine carabaos were still growing after 78 months of age, whereas the crossbreeds and the Murrahs were almost at a standstill.

Females. From birth to the last measurement at the 84th month the crossbreeds were the fastest in increase in height at the withers, the Philippine carabaos ranked second during the first three months, but third for the rest of the period. From the third month on, the Murrahs were second to the crossbreeds except in the 21st month when the increase in height was 3.13 per cent slower than in the Philippine carabaos. From the 30th month to maturity the Murrahs were a very close second to the crossbreeds in rate of increase. From the 60th month on, the crossbreeds and the Murrahs made very little increase over the Philippine carabaos.

Heart girth at birth

The averages of the heart girth of the males and females at birth showed that the crossbreeds ranked first, the Philippine carabaos second, and the Murrah carabaos third.

The heart girth of the males at birth compared with that of the females of the three breeds showed that the males of the Philippine carabaos and of the Murrah had a larger heart girth than the females, whereas in the crossbreeds the females had a larger heart girth at birth than the males.

Growth of heart girth

Males. The ranking in growth in heart girth of the males at one month of age is as follows: Philippine carabaos, first; crossbreeds, second; and Murrahs, third. From the 2nd month to the 42nd month the crossbreeds were first, and the Murrahs second up to the age of 42 months. From this time, however, the Philippine carabaos ranked second. In the 36th and 60th months the Murrahs were again second to the crossbreeds in rate of increase and the Philippine carabaos third. Towards the end of the fourth year, however, the Murrahs increased in girth faster than the cross-

breeds, which were ahead of the two breeds most of the time in growth of girth. The Philippine carabaos grew slowly though continually to maturity.

Females. The growth of heart girth among the females of the crossbreeds was always faster than in the other two except in the 2nd month when the Murrahs had a larger heart girth than the crossbreeds. During the 78th month the Philippine carabaos excelled the other two groups. The heart girth of the Murrah carabaos was between that of the crossbreeds and that of the Philippine carabaos but was almost the same as that of the Philippine carabaos during the 3rd and 4th months. In the 21st, 60th, 72nd, and 78th months the heart girths of the Murrah carabaos and of the crossbreeds were smaller than the heart girth of the Philippine carabaos, which most of the time ranked third in growth.

Circumference of the barrel at birth

In both sexes, the crossbreeds had the largest circumference of the barrel at birth, the Philippine carabaos the second largest, and the Murrahs the third.

The size of barrels of the males compared with that of the females of the same blood composition showed, however, that all the males had larger barrels than the females.

Growth of the circumference of the barrel

Males. In the three groups of animals, the growth of the circumference of the barrel of the males was nearly the same from birth to the 6th month. After six months the barrel circumference of the crossbreeds and of the Murrahs fluctuated, whereas that of the Philippine carabao increased steadily though slightly except towards maturity. The crossbreeds had the largest barrel from birth to the 60th month. In the fourth year, however, the Murrah carabaos had slightly larger barrels than the crossbreeds, and the Philippine carabaos had the smallest. During the first three months, the Philippine carabaos were second to the crossbreeds in size of barrel. In the 4th month the Murrahs had larger barrel than the other two breeds, and in the 5th month the Philippine carabaos had the largest. From the sixth month to maturity, the Murrah and the Philippine carabaos changed places for second but the crossbreeds were always first. The Murrahs were smaller than the Philippine carabaos in circumference of barrel, the measurements being as follows: at birth, 2.34 per cent; in the 30th month, 7.68 per cent; in the 42nd month, 1.12 per cent; and in the 54th month, 1.06 per cent.

Females. During the first nine months, the increase in circumference of the barrel of the female Murrahs and of the crossbreeds fluctuated so that one group would outincrease the other group in circumference of the barrel at one time and be outincreased the next. The Philippine carabaos

remained third. The same was true of the three groups with regard to the measurement of the circumference of the barrels during the first 12 months. From the 15th month to about the 22nd month the Philippine carabaos had larger barrels than the Murrahs, but the crossbreeds had the largest barrels up to the 54th month. From the 24th to the 40th month the Murrahs ranked second. From the 63rd to the 84th month, the Philippine carabaos were second in rank and the Murrahs, third.

SUMMARY

1. Among the Murrah and the Philippine carabaos and their crossbreeds that were studied, the Philippine carabaos weighed the lightest at birth. The crossbreeds were the heaviest at birth and the Murrahs intermediate between the two. The same was true in the increase in weight: the crossbreeds made the greatest gain.

2. In height at the withers, the males of the crossbreeds were the tallest at birth, followed by the Philippine carabao, Murrah carabaos being the smallest. The females of the Philippine carabao ranked first in height at withers, the crossbreeds second, and the Murrahs third. In rate of growth, the crossbreeds grew fastest, and the Murrahs faster than the Philippine breed. At maturity the males of the crossbreeds were the tallest, with the Murrahs not far behind; the Philippine carabaos were much shorter. The same was true of the females of the two breeds and their crossbreeds, although the Philippine carabaos were only slightly shorter than the Murrah carabaos and their crossbreeds.

3. The crossbreeds had the greatest heart girth, the Philippine carabaos, the next greatest, and the Murrah carabaos, the least. The rate of growth of heart girth in both sexes was fastest in the crossbreeds, less in the Murrahs, and the least in the Philippine carabaos, except at the mature age when the rate in the females changed the ranking to Philippine carabaos first, Murrahs second, and crossbreeds third.

4. In circumference of the barrel, the crossbreeds had the longest at birth, and the Murrahs, the shortest. In rate of growth of the circumference of the barrel the males of the crossbreeds were the fastest. The Murrahs ranked second but much slower than the crossbreeds. The Philippine carabaos were a close third and sometimes even nosed the Murrahs out of second place. Among the females, the ranking is as follows: crossbreeds, Murrahs, and Philippine carabaos.

5. The males had longer heads than the females at birth. In rate of growth of the head of both sexes, the crossbreeds were faster than either the Murrahs or the Philippine carabaos. Cessation of growth of the head, however, came at an earlier age in the crossbreeds, later in Murrahs, and latest in the Philippine carabaos. At maturity the ranking as to length of

head was as follows, the first having the longest head: Murrah, crossbreeds, and Philippine carabaos.

From birth to maturity the Philippine carabaos of both sexes had the narrowest width of the head. The males of the crossbreeds had wider heads than the Murrah carabaos up to the 33rd month. At maturity, however, the Murrah carabaos had wider heads than the crossbreeds. From two months to maturity, the heads of the female Murrahs were widest, closely followed by those of the crossbreeds.

Thirty-one per cent of the males and eight per cent of the females of Murrahs were born with horns, so that during the early period of their life many of the Murrah carabaos had longer horns than the Philippine carabaos and the crossbreeds. As the animals grew older, however, the horns of the crossbreeds and of the Philippine carabaos emerged and grew very fast. At maturity the Philippine carabaos had the longest horns and the Murrahs, the shortest.

In circumference of the horn the males exceeded that of the females of the same breed from the age of one month to maturity. The horns of the Murrah males had the largest circumference from the age of one month to one year, those of the crossbreeds the second largest, and those of the Philippine carabaos the third largest. From the 12th to the 42nd month the order changed to crossbreeds first, the Murrah carabaos second, and the Philippine carabaos third. The circumferences of the horns of the Philippine carabaos and of the Murrah carabaos were almost the same when the animals were five years old; they measured 35.33 cm. and 35.00 cm., respectively, whereas those of the crossbreeds measured only 33.00 cm.

The horns of the female crossbreeds had the largest circumference up to four and a half years, closely followed by those of the Murrah carabaos and the Philippine carabaos. At maturity, however, the circumference of the horns of the female animals studied were about the same.

6. The crossbreeds of both sexes had the deepest chests at birth. Among the males, the Murrah carabaos had deeper chests than the Philippine carabaos. The female Philippine carabaos, however, excelled the Murrahs at birth. The increase in depth of chest in both sexes was fastest in the crossbreeds, the Murrah carabaos coming second. At maturity, however, the increase in depth of the chest of the males of the Murrah carabaos equalled that of the crossbreeds. In the females, the chest was deepest in the crossbreeds and less deep in the Philippine carabaos but still deeper than in the Murrahs.

The male crossbreeds excelled the other breeds in rate of increase of the width of the chest. The Philippine carabaos had the narrowest chest almost throughout the whole period of observation. At maturity, there was a tendency for the Murrahs to have slightly wider chests than the crossbreeds.

During the first three years the females of the crossbreeds would have now slower, now faster growth of the width of the chest than the Murrah carabaos, the Philippine carabaos having the slowest width-growth. After three years and a half the females of the Murrah carabaos increased the fastest in width of chest most of the time, whereas the crossbreeds and Philippine carabaos contested for the second place.

7. At birth the males of the Murrah carabaos had the longest back and the Philippine carabaos, the shortest. The female crossbreeds had the longest back, and the backs of the Murrah and the Philippine carabaos measured equally.

The ranking on the rate of increase of the length of the back for both males and females was crossbreeds first, Murrah carabaos second, and Philippine carabaos third.

8. The males of Murrahs were second to the crossbreeds from birth to maturity in increase in length of rump. In the 24th, 27th, 30th, and 36th months, however, the Philippine carabaos were second and the Murrah carabaos, third.

From birth to maturity the females of the Philippine carabaos were most of the time second to the crossbreeds, and the Murrahs third.

In size of loin the males of the crossbreeds had the widest from birth to the 36th month and the Murrahs, second. As the animals approached maturity, however, the Murrah carabaos had the widest loin and the Philippine carabaos, the narrowest.

10. The males of the crossbreeds had the longest forearm from birth up to 33rd month and the Murrah carabaos the second longest. At 36 months of age the Philippine carabaos had slightly longer forearms than the crossbreeds and the Murrahs, the shortest. From the 36th month to maturity, the Murrah carabaos ranked with the crossbreeds for longest forearms.

Among the females the crossbreeds had the longest forearms at birth, and those of the Philippine and Murrah carabaos were of the same length. From the 2nd month to the end of the 6th month, the Murrah carabaos had slightly longer forearms than the crossbreeds. After the 6th month, however, the crossbreeds had the longest forearms, with those of the Murrah carabaos and the Philippine carabaos coming in the order mentioned.

11. From birth to maturity there seemed to be no significant difference in the development of foreshank, although the crossbreeds had a tendency to have the longest foreshank and the Philippine carabaos, the shortest.

12. No marked difference was noted in the length and growth of the front hoof from birth to maturity in both sexes of the animals studied.

The increases in weight and important body measurements from birth to maturity of the crossbreeds are expressions of hybrid vigor, or heterosis, manifested by the Philippine-Murrah carabao crossbreeds.

A PHOTOCHEMICAL REACTION OF SOME VEGETABLE OILS WITH CHLORINE GAS[1]

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WITH ONE TEXT FIGURE

In 1937, while working on the chemical saturation of products of pyrolysis of coconut oil, the writer obtained a resin-like substance which was found to be the result of a chemical reaction of chlorine and coconut oil. Experiments demonstrated that the same results could easily be obtained with other vegetable oils provided that the oil and the chlorine were exposed to strong sunlight, indicating that the reaction is probably photochemical in nature.

Review of literature

Available literature shows that the reaction of vegetable oils with chlorine received attention in the past, but it seems that the accelerating effect of light was not recognized.

Gardner and Bielouss (1922) chlorinated petroleum and other oils with the aid of heat. By a process of dechlorination they were able to convert petroleum into drying oils.

Vibar and Birosel (1936) applied the chlorination-dechlorination method to lumbang oil with the aid of heat (100° C.) and after nine hours of chlorination, the result was a very viscous oil.

Pilar Herrera-Batteke and José P. Marcelo, in a paper on the hydroxylation of coconut oil which was read before the Third Philippine Science Convention held in Manila from February 26 to March 2, 1935, reported the chlorination of coconut oil with the aid of phosphorous trichloride as a catalyst.

MATERIALS

The vegetable oils used in this study were the commercial kind. The coconut-oil fatty acids were prepared by the usual method of saponifying with sodium hydroxide and decomposing the soap thus formed with dilute hydrochloric acid. The resulting mixed fatty acids were washed three times with warm water and dried. The coconut-oil ethyl esters were prepared by the reaction of coconut oil with ethyl alcohol catalyzed by HCl[2].

Chlorine for this investigation was obtained from a regular commercial tank.

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[1] Experiment Station Contribution No. 1486.

[2] BANZON, J. On the reaction of coconut oil with ethanol. Read before the Fourth Philippine Science Convention, Manila, February 25, 1937.

EXPERIMENTS AND DISCUSSION

Method of chlorination. Fifty milliliters of the oil under study were placed in an ordinary 15-cm. test tube with a side tube. Chlorine from a tank was allowed to bubble through the oil at the rate of 5 to 7 bubbles per second. A sketch of the apparatus is shown in figure 1-A. The flask containing the oil was exposed to the full intensity of the midday sun.

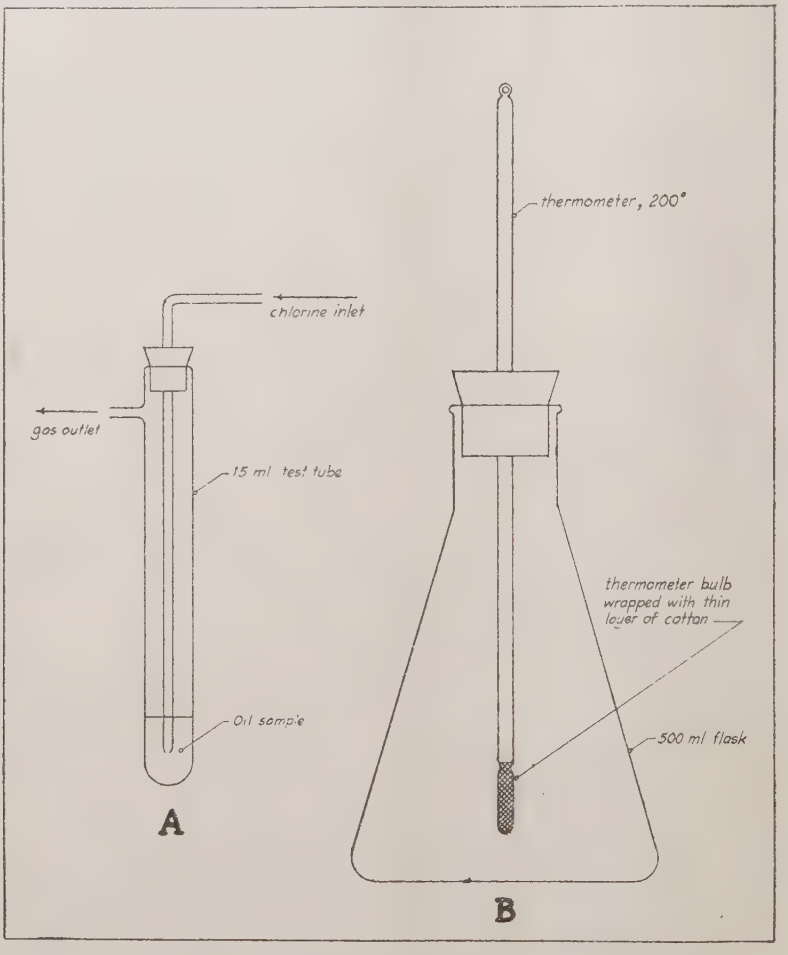


Fig. 1.—Sketch of the apparatus used in the chlorination.

The reaction was strongly exothermic. The temperature of the coconut oil rose to 150°C. Fumes of HCl gas were evolved in large amounts and numerous small bubbles were formed in the mass of the oil. A peculiar suffocating odor, probably from some chlorinated product, became evident. Within two hours of continuous chlorination, the oil became very viscous

and sticky. When the process was undertaken in the shade, the reaction slowed down considerably as shown by the thermometer. Variations in sunlight intensity caused by passing clouds had a similar slowing-down effect. The reaction, therefore, was largely, if not entirely, photochemical in nature.

The following oils were each separately subjected to the chlorination procedure described above: castor, corn, linseed, lumbang, peanut, and coconut as well as the mixed fatty acids and mixed ethyl esters from coconut oil. In all the chlorinations a viscous sticky product was obtained. Linseed and lumbang oils became dark and the other oils also had the tendency to darken, especially when the rate of chlorine flow was increased.

The product formed in the case of coconut oil and its derivatives (the fatty acids and the ethyl esters) was a transparent, very sticky semisolid. A white hard crust often formed at the surface after a certain length of time. When heated it became more liquid, numerous bubbles were formed (presumably HCl from partial dechlorination), and the product became hard upon cooling. This hard product was obtained easily if the chlorination was performed with the use of a solvent. A notable property of the chlorinated product was noninflammability. It did not burn even when a flame was brought in contact with it although upon persistent application of high temperature, it decomposed, forming gaseous products which burned. Boiling with alcoholic NaOH or KOH up to one normal concentration did not seem to have any visible effect on the chlorinated product.

Because the high viscosity interfered with the passing of chlorine gas into the oil at the later stages of the chlorination process, the possible ultimate product was difficult to obtain. A very thin film of oil placed at the bottom of an Erlenmeyer flask and chlorinated for hours resulted in a white solid.

Chlorination in solution. Ten milliliters of coconut ethyl esters were dissolved in 80 ml. 95 per cent ethyl alcohol and chlorinated in sunlight. The reaction was violent. Red flames with soot were produced in the liquid. Chlorination in the extreme was probably taking place, whereby all hydrogen atoms of the oil were stripped off by the chlorine, leaving only carbon in the form of soot. During the chlorination, an oily layer immiscible with the alcohol was formed.

Chlorination of coconut oil dissolved in carbon tetrachloride proceeded smoothly. After four hours of chlorination, the solvent was evaporated in an open dish. When most of the CCl_4 had evaporated, small bubbles were evident in the mass of the hot liquid. On cooling, a hard resinlike solid, devoid of its former sticky properties, was obtained. Carbon tetrachloride was favored as a solvent for chlorination because of its nonreactivity toward chlorine.

Amount of chlorine involved.— The increase in weight of the oils upon chlorination is given in table 1. The highest percentage increase was obtained with coconut ethyl esters (126.7 per cent); the lowest, with castor oil (46.5 per cent). Coconut oil gave a higher percentage increase in weight (80.5 per cent) than linseed (59.7 per cent), lumbang (51.7 per cent), corn (64.5 per cent), or peanut (54.2 per cent) oils. These results are contrary to expectations because the more unsaturated oils (linseed, lumbang, etc.) reacted with smaller amounts of halogen than coconut oil, which is quite saturated. In table 2 is given the iodine number, which is a measure of unsaturation, the percentage increase in weight of the various oils upon chlorination, and the percentage composition of the oils according to Jamieson (1932).

The actual increase in weight of the oil sample upon chlorination is not equal to the weight of combined chlorine. In the case of the saturated components of the oils, the reaction involved is most probably the replacement of a hydrogen atom by a chlorine atom. The net increase in weight is the result of adding a chlorine atom to the oil molecule and subtracting a hydrogen atom. For example,

Let x = weight of Cl emplaced
y = weight of H displaced
$x - y$ = net increase in weight of the oil $= \Delta w$
According to relative atomic weights,

$$x = 35.5y$$

$$x - \frac{x}{35.5} = \Delta w$$

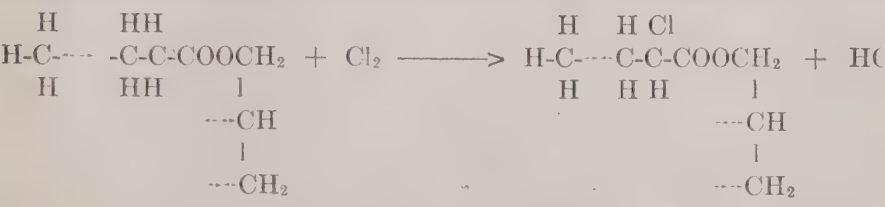
$$x = 1.03\ \Delta w$$

The above relationship shows how the actual weight of combined (or emplaced) chlorine can be calculated from the increase in weight of the sample when the chlorination takes place by replacement. It is also shown that the weight of combined chlorine is almost identical with the increase in weight.

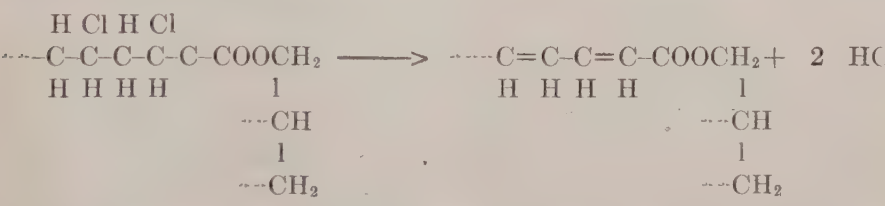
When the reaction of chlorine is by addition, no hydrogen is displaced and the increase in weight of the sample is equal to the weight of the entering chlorine. Whether the reaction be by replacement or by addition, no serious error will be made, therefore, at this stage of the investigation if the increase in weight of the oils is taken as the weight of chlorine emplaced or chemically combined with the oil sample.

The amount of chlorine involved in these chlorinations was large. By weight, it ranged from 46 to 126 per cent of the weight of the oil. These quantities of chlorine become even more marked if volumes of halogen gas instead of weights are calculated, as given in table 1.

Probable mechanism of the photochlorination reaction. The absorption of chlorine by the unsaturated oils (linseed, lumbang, corn, peanut) is to be expected; chlorine in all certainty adds to the double bond. In the case of the more saturated oils (coconut, its fatty acids and ethyl esters), reaction with large quantities of chlorine can be explained only by chemical replacement of hydrogen atoms by the halogen, which reaction, according to the results here presented, is promoted by the presence of strong sunlight. In the case of glycerides, the initial reaction may be formulated as follows:



The liberation of hydrogen chloride gas in large quantities during the photochlorination process is an evidence for the given formulation of the reaction. What remains to be demonstrated is which carbon atom (not necessarily the α-carbon atom as shown above) is first attacked by the entering chlorine; and after the first chlorine atom has entered, which carbon atom is next attacked, and so on. Information on the relative reactivities of the carbon atoms in an aliphatic chain and the influence of prior substitution is lacking. This information is of considerable importance because if the chlorine should attach to every other carbon, then conjugated double bonds should be obtained by dechlorination with the elimination of HCl as the following shows:



The transformation of the semisolid chlorinated oil into a rather hard resinlike solid upon heating is very probably explainable by the mechanism of dechlorination given above. If this explanation is substantially correct, then to obtain a complete system of conjugation, 50 per cent of the hydrogen atoms would have to be replaced by chlorine.

Attempts to chlorinate glycerol under the conditions employed in this investigation always failed; however, the chlorination of the mixed fatty acids and of their ethyl esters took place as readily as that of the parent coconut oil. These results indicate that chlorination takes place in the aliphatic chain of the fatty acid and not in the glyceryl radical of the glyceride molecule.

Since coconut oil, as well as its fatty acids and ethyl esters, combines with more chlorine than the other oils studied, the process of chlorination-dechlorination should work more successfully with coconut oil and its derivatives than with other oils. Results so far obtained indicate that it is not necessary to remove all the chlorine by dechlorination. A mild heat treatment of the chlorinated product resulted in a resinlike, nonbrittle solid which, dissolved in a suitable solvent, can be used for surface coatings.

Measurements of temperature rise. The reaction of chlorine with the oil samples was found invariably accompanied by the evolution of heat. A thermometer placed in the oil being studied indicated that the various oils differed from each other in two respects: in the temperature rise or maximum temperature attained and in the length of time required to reach this maximum. To study further this evolution of heat the following technique was evolved:

A clean 500-ml. Erlenmeyer flask was fitted with a rubber stopper carrying a thermometer as shown in figure 1-B. The entire bulb of the thermometer was wrapped firmly with a layer of absorbent cotton sufficiently thin for the bulb to be visible through the cotton. The cotton was moistened with a few drops of the oil under study, care being taken not to allow any oil to drop to the bottom of the flask. The flask was filled with dry chlorine from a tank by upward displacement of the air. The oil-soaked thermometer bulb was inserted into the flask, adjusted to a height of 2 to 3 cm. from the bottom, and the entire assembly exposed to direct noon sunlight. The flask was inclined slightly so that the shadow of the rubber stopper did not fall on the thermometer bulb. Temperature readings were taken every 15 seconds. The results of the measurements on various oils are given in table 3.

It will be seen from these results that linseed and lumbang oils attained the highest temperatures in a very short time. The coconut oil, its fatty acids, and ethyl esters did not attain very high temperatures but required from three to four times as long to reach maximum temperature. An examination of the iodine numbers (table 3) indicates that the larger the iodine number the greater was the temperature rise and the shorter was the time required to reach the maximum temperature during photochlorination. These two measurements, the rate of temperature rise and the maximum temperature attained, may possibly be used in the identification of vegetable oils. The method is much simpler than that for the iodine number. Because the only reagent was chlorine from a tank, it required no preparation and standardization of reagents and the determination could be done in a few minutes.

SUMMARY

1. In strong sunlight chlorine gas was found to react with some vegetable oils (linseed, lumbang, corn, peanut, castor, coconut, and the fatty

acids and the mixed ethyl esters from coconut oil with the formation of a very viscous sticky resinous mass. There are evidences that the reaction is photochemical in nature.

2. There are indications also that the chlorine atoms attach themselves to the aliphatic chain and not to the glyceryl radical.

3. The increase in weight of the oils due to this photochemical reaction was found to be as much as 126 per cent in the case of the coconut ethyl esters, indicating that large amounts of chlorine were involved in the reaction.

4. Of the oils studied those that had higher unsaturation combined with less chlorine than those with lower unsaturation. The iodine number of these oils was found to be directly proportional to the temperature rise and inversely proportional to the length of time required to reach the maximum temperature.

5. The results of this study indicate the possibility of identifying an oil from the rate of temperature rise and the length of time it requires to attain the maximum temperature. A technique which requires a shorter time, simpler apparatus, and more easily prepared reagents than those necessary for the iodine number determination is described.

6. A mechanism for photochemical reaction with chlorine gas is described. The formation of a hard resinlike substance upon heating is explained by a dechlorination reaction in which hydrogen chloride gas is evolved. It is also shown that if by photochlorination, an atom of chlorine can be made to attach itself to every other carbon atom in the aliphatic chain, then dechlorination by the removal of neighboring H and Cl atoms should result in a compound with conjugate double bonds.

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TABLE 1

Increase in weight of various oils upon chlorination in sunlight and the corresponding volume of chlorine absorbed

MATERIALS USED	WEIGHT OF SAMPLE	INCREASE IN WEIGHT	CHLORINE ABSORBED
	grams	*per cent*	*ml. per gram sample*
Castor	3.7145	49.17	
	3.8848	43.74	
	Average	46.45	14.6
Lumbang	4.3189	46.46	
	3.5110	56.97	
	Average	51.71	16.6
Peanut	3.8934	56.30	
	3.8626	52.07	
	Average	54.18	17.2
Linseed	2.8889	56.56	
	3.2568	62.87	
	Average	59.71	18.8
Corn	2.1075	64.82	
	2.6010	64.09	
	Average	64.45	20.00
Coconut	4.4173	72.83	
	4.4449	79.42	
	4.1345	89.33	
	Average	80.53	25.2
Fatty acids (mixed) from coconut	3.5060	96.82	
	3.0714	91.63	
	Average	94.23	29.6
Ethyl esters (mixed) from coconut	2.3910	129.23	
	2.1690	124.26	
	Average	126.74	39.7

TABLE 2

Iodine number and chemical composition of various oils in relation to amount of combined chlorine upon chlorination in sunlight

OIL	PERCENTAGE COMPOSITION [a]				INCREASE IN WEIGHT	IODINE [a] NUMBER
	Oleic	Linoleic	Linolenic	Ricinoleic		
					per cent	
Linseed	5	48.5	34.1	—	59.7	189–196
Lumbang	54.3	32.0	6.3	—	51.7	190–193
Corn	43.4	39.1	—	—	64.4	188–193
Peanut	52.9	24.7	—	—	54.2	83–95
Castor	9	3	—	80	46.4	82–90
Coconut	2–5	1	—	—	80.5	8–10

[a] Jamieson, 1932

TABLE 3

Temperature rise and time required to attain maximum temperature during chlorination of various oils in sunlight and their relationship with the iodine number

OIL	MAXIMUM TEMPERATURE RISE		TIME TO ATTAIN MAXIMUM TEMPERATURE		IODINE[a] NUMBER
	Mean	Range	Mean	Range	
	°C.	°C.	seconds	seconds	
Linseed	165	135–189	60	45–75	189–196
Lumbang	158	146–173	66	45–90	190–193
Corn	125	111–144	63	60–75	188–193
Peanut	118	110–129	108	90–135	83–95
Castor	118	108–125	132	90–180	82–90
Coconut	94	75–112	248	225–285	8–10
Fatty acids (mixed) from coconut	99	92–115	300	270–285	—
Ethyl esters (mixed) from coconut	84	79–88	258	210–315	—

[a] Jamieson, 1932

STUDIES ON A PHOTOCHEMICAL REACTION OF COCONUT OIL WITH CHLORINE GAS[1]

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A reaction of some vegetable oils with chlorine gas was reported to be accelerated by light (Banzon, 1948). Inasmuch as the reaction may be of some importance not only as a potential starting point for organic synthesis, but also as a direct method of converting coconut oil into a resinous material possessing certain desirable properties, further investigation of this reaction was deemed advisable.

Review of literature

Chlorination of petroleum oils was reported by Gardner and Bielouss in 1932. Vibar and Birosel (1936) chlorinated lumbang oil. Pilar Herrera-Batteke in 1935 read before the Fourth Philippine Science Convention in Manila, a paper describing the partial chlorination of coconut oil. It appears that these chlorinations were performed with the aid of heat, but the rôle of light in greatly accelerating the reaction seems to have been overlooked. The fact that strong light is avoided in the determination of the iodine number of fats and oils suggests that in the presence of light, halogenation by replacement in fats and oils had been noted in the past. Banzon (1948) reports that in direct sunlight chlorine gas reacted vigorously with a number of vegetable oils, indicating that the process was probably photochemical.

MATERIALS AND METHODS

Four samples of coconut oil were used in this investigation: oil prepared in the laboratory by the "bacterial method," alcohol-washed; the same oil alkali-refined; commercial oil purchased in the local market; and oil prepared by the usual method of heating the milky juice obtained by squeezing grated coconut endosperm.

The chlorine gas was obtained from a regular commercial tank.

The light filters were 5-cm. square, manufactured by the Eastman Kodak Company (Wratten Filters). According to the manufacturer the filters have the following transmissions:

C-5 (No. 47), blue, transmitting 3700-5100 Å
B (No. 58), green, transmitting 4800-6200 Å
A (No. 25), red, transmitting 5900 to red end of spectrum (about 7000 Å).

[1] Experiment Station Contribution No. 1487. Based on the thesis presented by the junior author for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, June, 1947. Prepared under the direction of the senior author.

The pycnometers were glass bulbs of about 5-ml. capacity, made specially for this study. Test tubes 15 cm. in length were used as reaction vessels. A side tube was joined to each test tube to serve as exit for any excess chlorine or any gaseous by-product. An Abbe refractometer made by Bausch and Lomb was used to measure refractive indices.

The saponification number and the iodine number were determined according to specifications of the Association of Official Agricultural Chemists (1935).

The combined chlorine was determined qualitatively in the reaction products by the usual sodium-fusion method, followed by the silver-nitrate test for halogen.

The apparatus used in these studies consisted basically of a 15-cm. test tube with a fused-in side tube and a gas inlet tube passing through the center of a cork stopper (Banzon, 1948, fig. 1). The sample was placed in the test tube and weighed; chlorine gas was allowed to bubble through the oil by way of the inlet tube.

EXPERIMENTS AND DISCUSSION

Strong sunlight is an essential condition for the reaction of coconut oil with chlorine (Banzon, 1948). This investigation is concerned with the determination of the effect of the various conditions of illumination on the reaction. The following degrees of illumination were studied: direct sunlight, cloud-diffused sunlight, darkness, electric light, and the blue, green, and red portions of the solar spectrum. The effect of temperature was also included in this study because it appears that other investigators have depended on high temperature to accelerate the reaction.

Chlorination in sunlight. Chlorine was allowed to bubble through the oil sample (3 to 4 grams) at the initial rate of 3 bubbles per second. The entire assembly was placed in direct sunlight. Chlorination was undertaken only on selected cloudless days of March, April, and May, and between 9:00 A.M. and 3:00 P.M. The sample was weighed hourly.

The changes previously reported were readily observed: the tubes became hot, indicating an exothermic reaction; fumes, presumably a by-product of hydrogen chloride gas, were liberated in quantity; a peculiar odor due probably to some volatile chlorinated product became evident; the oil "thickened" rapidly, becoming sticky and semisolid.

The percentage increase in weight of the sample, based on the original weight, is given in table 1. The increase in weight of the four samples of coconut oil after four hours of chlorination was from 81.1 to 92.1 per cent of their original weight. This result indicated that the method of preparation of the oil has a negligible effect on the quantitative reaction with chlorine gas. It appears then that coconut oil can combine with so much chlorine in direct sunlight as to double almost its original weight.

When chlorination was undertaken in cloud-diffused sunlight, the percentage increase in weight of the oil samples was much lower than that obtained in strong sunlight. This is shown in table 1.

Chlorination in the dark. The apparatus for chlorination was enclosed in a light-tight box and precautions were taken to make the gas entry and exit by way of coiled opaque rubber tubing to insure exclusion of light. Samples were weighed in the tubes as usual and placed in the box, and chlorine gas was allowed to bubble through the oil. As shown in table 1, upon chlorination the coconut oil increased in weight even in the dark. This result was expected inasmuch as there is some unsaturation in coconut oil, the iodine number of the sample being 9. A calculation of the amount of chlorine corresponding to this iodine number may be made as follows:

Iodine number of the sample = 9.08 or 1 gram of the oil combined with 0.0908 gram iodine. The equivalent weight of chlorine would be

$$\frac{0.0908}{127} \times 35.46 \text{ or } 0.02635 \text{ gram chlorine.}$$

The coconut oil sample was therefore expected to increase in weight by 6.2 per cent. Actually the increase was 27.2 per cent (table 1). There is evidence therefore that chlorination can take place even in the dark although the reaction is quite slow.

Chlorination under an electric lamp. A 100-watt tungsten bulb was placed 20 cm. from the oil sample being chlorinated. All other lighting was excluded. This was best accomplished by working in the early evening. The results of chlorinations under these conditions are also given in table 1. The illumination from a 100-watt tungsten bulb appears to be comparable to diffused sunlight in accelerating chlorination of coconut oil. The use of lamps instead of sunlight is a point of advantage in connection with reliability and control of intensity. The method described by Banzon (1948) for identifying vegetable oils by temperature rise during chlorination would be enhanced if a standard lamp could be used instead of sunlight.

Chlorination under light of limited wave lengths. Inasmuch as the light from a tungsten bulb consists mainly of the red and yellow portions of the spectrum, as well as the longer infrared, the effect of light of definite wave lengths was next studied. Wratten filters were used to secure the three bands of transmission from visible solar radiation: the blue, comprising wave lengths between 3700 and 5100 Å; the green, with 4800 — 6200 Å wave lengths; and the red, with wave lengths from 5900 Å to the end of visible red. Chlorinations were undertaken by exposing the sample to direct sunlight with the filter interposed so that illumination passed through the filter.

The results (table 1) show that chlorination started slowly under the red portion of the solar spectrum, the sample increased in weight by only 10

per cent, compared with 61 per cent under the green, 45 per cent under the blue, and 84 per cent under direct sunlight. At the end of four hours, however, the percentage increase in weight tended to equalize, although the red region of the spectrum remained less effective than the others in inducing chlorination. A long period of induction seemed to be indicated for the reaction when carried under the red rays. Since the relative intensities of light coming through the filters were not measured, comparisons are at best only qualitative. There was an indication, however, that the chlorination took place more rapidly in the blue portion of the spectrum. It is of course generally known that the shorter wave lengths are associated with greater energies and are more effective chemically than the longer wave lengths. For this reason, further studies employing ultraviolet lamps are being continued.

Chlorination at 100°C. As a number of investigators attempted chlorination of oils with the aid of heat, coconut oil was heated to 100°C. in a water bath and then chlorinated. In order to eliminate the factor of light, the reaction vessel was totally covered. The results (table 1) show that the chlorination at 100°C. was about the same as that in the dark. The effect of temperature, therefore, appears to be negligible. The temperature coefficient of photochemical reactions are generally known to be small; hence, this result is another evidence of the photochemical nature of the reaction.

Amount of chlorine introduced into the coconut oil glyceride. The increase in weight of coconut oil upon chlorination is not equal to the weight of combined chlorine. If the chlorination is by replacement, and there are strong evidences that it is, then the weight of actually combined chlorine may be calculated from the equation previously given:

$$x = 1.03\Delta w$$

where x = weight of combined chlorine

Δw = increase in weight of the sample.

By computing the data given in table 1, values were obtained which are shown in table 2. The results are expressed as weight of chlorine per gram of original weight of oil. By dividing the weight of combined chlorine by the actual weight of the chlorinated product, the percentage of chlorine in the product was obtained. Thus, in four hours of chlorination in direct sunlight, the weight of combined chlorine was 0.948 (table 2); the weight of the chlorinated product was 1.921 (table 1). The percentage of chlorine was, therefore, 49.3 (table 2).

The four hours of chlorination in direct sunlight resulted in a product containing 46.7 per cent combined chlorine. In a separate experiment, as high as 55.3 per cent combined chlorine was obtained in direct sunlight

and slightly lower figures were obtained when filters were used. When chlorination was undertaken at 100°C., the product was found to contain only 24.6 per cent chlorine.

By dividing the number of gram atoms of chlorine by the apparent number of moles of oil, the number of gram atoms of chlorine per mole oil was obtained. For this calculation, the average molecular weight of the oil was obtained from a determination of the saponification number. This latter value was found to be 258.7 and the calculated average molecular weight was 650. The last column of table 2 gives the calculated values of gram atoms chlorine per mole oil. These figures indicate the computed number of chlorine atoms that entered one apparent molecular weight of the original oil.

Physical properties of the chlorinated product

1. Color, odor, taste, and consistency. The chlorinated product was yellowish brown. After chlorination the product retained the odor of chlorine and hydrogen chloride gases, but when allowed to stand for a number of hours it became almost odorless and tasteless. The reaction product was a thick semisolid.

2. Specific gravity. The specific gravity of the original oils at 31°C. ranged from 0.916 to 0.920 (table 3). After chlorination the product possessed a specific gravity at 31°C. ranging from 1.349 to 1.718.

3. Refractive index. The refractive index of the oil samples varied from 1.452 to 1.455. The products after chlorination had refractive indices ranging from 1.506 to 1.512.

4. Solubilities. The chlorinated oil was found to be soluble in carbon tetrachloride, furfural, acetone, chloroform, and toluene, and insoluble in gasoline and in 95 per cent ethyl alcohol. The original sample of oil was soluble in all of these solvents except in 95 per cent ethyl alcohol.

Chemical properties of the chlorinated product

1. Saponification number. The saponification number of the original oil samples ranged from 255.8 to 260.7. There was difficulty in determining the saponification number of the chlorinated products because the alcoholic potassium hydroxide, upon boiling with the chlorinated product, became highly brownish, thus interfering with the color change of phenolthalein. The saponification number of the chlorinated product could not be accurately determined, but duplicate determinations gave values of 255 and 270.

2. Iodine number. The untreated oil had an iodine value of 8.6 to 9.4, but the chlorinated oil had an iodine value of practically zero.

3. Presence of chlorine in the product. The various samples of chlorinated coconut oil subjected to qualitative tests for chlorine gave positive results. Both the sodium-fusion method and the copper-wire method showed the presence of combined chlorine in the chlorinated product. There is, therefore, evidence that the chlorine atoms have become part of the coconut oil glyceride molecules.

SUMMARY

1. Chlorination of coconut oil was conducted under the following conditions: direct sunlight, cloud-diffused sunlight, complete darkness, electric light, filtered sunlight, and increased temperature (100°C.).

2. Chlorination in strong direct sunlight caused the introduction of the greatest amount of chlorine.

3. Of the three ranges of wave lengths studied, the filtered sunlight of short wave lengths appeared to be the most effective for chlorination.

4. Light from a 100-watt tungsten bulb did not cause as much introduction of chlorine as direct sunlight but was far more efficient than chorination with heat at 100°C.

5. The chlorinated product was an amber-colored, transparent semisolid containing about 50 per cent of its weight of chlorine and with a specific gravity at 31°C. of 1.520, and an iodine number of practically zero. It was soluble in carbon tetrachloride, furfural, acetone, and chloroform, but insoluble in gasoline, water, and ethyl alcohol.

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TABLE 1

Percentage increase in weight of samples of coconut oil upon chlorination under various conditions of illumination

CONDITION	HOURS CHLORINATION				REMARKS
	1	*2*	*3*	*4*	
Direct sunlight	66.7	74.6	86.9	92.1	Four different samples of oil were studied; figures are means of two trials.
	72.1	81.2	87.7	88.8	
	72.4	80.6	83.5	85.9	
	61.7	73.6	80.3	81.1	
Av.	68.2	77.5	84.6	86.9	
Diffused sunlight	23.7	33.8	48.6	66.7	Two samples of oil were used.
	12.4	38.4	53.6	79.0	
Av.	18.1	36.1	51.1	72.8	
Darkness	12.9	24.2	28.4	—	Only one sample of oil was used.
	19.8	24.1	26.0	—	
	20.5	25.1	27.1	—	
Av.	17.7	24.5	27.2	—	
100-watt electric bulb	37.1	60.5	61.1	—	Only one sample of oil was used.
	32.1	36.0	59.3	—	
Av.	34.6	48.3	60.2	—	
3700–5100 Å (blue)	45.3	95.5	104.5	100.5	Each figure is the mean of two trials.
4800–6200 Å (green)	61.1	78.0	84.7	92.8	
5900–7000 Å (red)	10.1	18.5	52.9	80.6	
Unfiltered light	84.3	106.9	108.8	107.0	
Heat (100°C.) and darkness	10.8	25.2	30.9	—	Only one sample of oil was used.
	24.8	28.1	32.0	—	
Av.	17.8	26.7	31.5	—	

TABLE 2

Calculated weight of combined chlorine per gram of oil, percentage chlorine in the product, and the number of gram atoms chlorine per apparent mole of oil

CONDITION	HOURS CHLORINATION	WEIGHT OF COMBINED CL.	PERCENTAGE CHLORINE IN PRODUCT	ATOMS CL. PER MOLE OIL
		grams		
Direct sunlight	4	0.948	49.3	17.3
		0.915	48.6	16.8
		0.885	47.6	16.2
		0.836	46.2	15.2
		Av. 0.896	47.9	16.4
Diffused sunlight	4	0.687	41.5	12.6
		0.814	45.5	14.8
		Av. 0.750	43.5	13.7
Darkness	3	0.292	22.7	5.3
		0.268	21.2	4.6
		0.279	21.9	5.1
		Av. 0.280	21.9	5.1
Electric light	3	0.629	39.0	11.5
		0.612	38.4	11.2
		Av. 0.620	38.7	11.3
3700–5100 Å (blue)	4	1.035	51.8	19.0
4800–6200 Å (green)	4	0.957	49.7	17.5
5900–7000 Å (red)	4	0.831	46.1	15.2
Unfiltered light	4	1.102	55.3	20.2
Heat (100°C.) and darkness	3	0.318	24.3	5.5
		0.329	24.9	6.0
		Av. 0.325	24.6	5.9

TABLE 3

Physical and chemical properties of the original oil and its chlorinated product

SAMPLE	REFRACTIVE INDEX	SPECIFIC GRAVITY	IODINE NUMBER
	31° C.	*31° C/31°C.*	
A. Original	1.453	0.916	9.08
Product	1.510	1.687	0.04
B. Original	1.454	0.917	9.08
Product	1.509	1.534	0.93
C. Original	1.455	0.920	—
Product	1.509	1.410	0.01
D. Original	1.452	0.920	—
Product	1.507	1.451	0.10

THE PERFORMANCE OF FIVE VARIETIES OF LOWLAND RICE[1]

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Aragon and Cada (1939) reported that among 10 varieties from the Federated Malay States, Seraup Kechil 36 is one of the highest yielders and, consequently, the most promising in the Philippines. These authors found that in the first year it required 169 days to mature, and in the second year, 175 days. It yielded, on the average, 68.83 cavans per hectare. In a later study, Calma and Cada (1941) found that Seraup Kechil 36 matured in 182 days after it was sown in the seedbed and gave a yield of 64.5 cavans per hectare. Ocfemia and Calma (1948) found that Seraup Kechil 36 matured in 163.4 days and gave a yield of 41.40 cavans per hectare.

In an experiment conducted from July, 1946, to February, 1947, in the Experiment Station field and in the laboratory of the Department of Agronomy, College of Agriculture, Los Baños, Laguna, Seraup Kechil 36 was among the five varieties of lowland rice studied.

EXPERIMENT, RESULTS, AND DISCUSSION

Preparation of the seedlings for planting

The seeds of Seraup Kechil 36 were furnished by the Department of Agronomy, and those of Quezon rice (Raminad strain 3) were obtained from Baliuag, Bulacan; those of Thailand, from Bay, Laguna; and those of Consejala and Raminad strain 2, from Malolos, Bulacan. The experiment was replicated three times for each variety.

On July 27, 1946, the seeds of each of the five varieties in separate gunny sacks were soaked in running water for 24 hours and then placed in a shaded place for another 24 hours to sprout the seeds. The sprouting grains were sown on July 30, 1946, in seedbeds prepared by the ordinary wet-bed method at the rate of 25 gantas to every 500 square meters.

The field and its preparation for cropping

A 4,500-square-meter portion of the lowland rice field of the College Experiment Station was used. The field, which is of clay loam soil, had not been planted to any other crop except rice. Fifteen rectangular paddies, each with an area of 300 square meters, were prepared in the ordinary way of preparing a lowland rice field and then numbered consecutively from 1 to 15.

[1] Experiment Station Contribution No. 1488. Prepared from the thesis of the junior author presented in April, 1947, for graduation with the degree of Bachelor of Science in Agriculture.

On September 15, 1946, water was turned into the seedbed to soften the soil and facilitate the uprooting of the seedlings. The following day the seedlings were pulled up, tied into small bundles, and piled separately on the side of the seedbed. The upper one-third of the seedlings were pruned. The bundles of seedlings were carried in baskets and placed in their respective paddies. The seedlings were 49 days old when they were transplanted. Two to three seedlings were planted in hills 25 centimeters apart.

No water was turned into the paddies after transplanting to give the seedlings time to establish themselves in the soil. The water in the nearby ditch was turned into the paddies when necessary, especially when there was no rain and the water in the paddies was low. On October 12, 1946, 28 days after transplanting and when the plants were 75 days old, some of the plants of the Thailand variety began booting. A week later, or 85 days after sowing in the seedbed, some of the plants began to flower. At this time, however the plants of Consejala, Quezon rice, Raminad strain 2, and Seraup Kechil 36 were still in the active vegetative stage. The plants of the five varieties, Quezon Rice in particular, were vigorous.

Degree of lodging and susceptibility to pests and diseases

Seraup Kechil 36 lodged the most, owing probably to the increase in weight of the grains of the panicles as the plants approached maturity. Quezon rice and Raminad strain 2 lodged heavily also, whereas Consejala lodged but very slightly. Thailand did not lodge at all probably because the panicles of this variety were empty, having been attacked by various pests.

The pests observed to attack the five varieties were the rice stem borer, *Schoenobius incertellus* Walker, which caused the appearance of dried panicles with empty grains, and the rice bug, *Leptocorisa acuta* Thunberg. The latter was responsible for the empty grains in some panicles, especially in the Thailand variety. The red rice weaver, *Lonchura ferruginosa jagori*, which fed on the grains, came from time to time as the different varieties approached the dough stage and till they matured. It was attempted to minimize the damage caused by these birds by placing scarecrows around the field, but this method was not very effective. Rats also destroyed the rice crop to some extent as evidenced by plants they had gnawed at the base and by remnants seen in the field of hulls from which they had extracted the kernels.[2] Grated coconut thoroughly mixed with arsenic trioxide poison was used as bait for rats. The application of this poison seemed effective, for dead rats along the dikes were seen in nearby paddies. A major loss of grains was caused by a kind of bat known to the local farmers

[2]Abesamis (1922) observed that rats caused the toppling over of some of the stalks of rice in his culture.

as "bayakan," although the identity of the species could not be ascertained as a specimen could not be secured. Efforts to bait and trap the bats were not successful. At night, the bats swooped down on the rice when it was still in the milk stage or when the seeds were almost mature, cut the panicles just below the last leaf, and carried them away whole. The attacked plants remained standing erect, and, except for the lost panicles, appeared uninjured. Uichanco (1946)[3] reported that in December, 1945, the fruit bats swooped down in flocks at night and nibbled off rice panicles in large patches in the field, ruining the work of at least three thesis students. These pests, being nocturnal, were not found to attack the rice crop during the day.

Thailand rice was entirely destroyed by bats, rats, and other pests because it reached the reproductive stage the earliest. It was attacked during the milk, the dough, and the maturing stages. Consejala was also attacked owing to the fact that it likewise reached the milk and dough stages quite early. The varieties Seraup Kechil 36, Quezon rice, and Raminad strain 2 were damaged very slightly because the flowering and the maturing of the grains occurred practically at the same time that they did in the greater part of the rice crop in the surrounding fields.

The false smut caused by *Ustilaginoidea virens* (Cke.) Tak. was present in some grains of a few panicles, but its damage was negligible.

Height of plants

In regard to the height of the plants of the four varieties at maturity the writers noted that Quezon rice was the tallest, with a mean height of 168.03 centimeters. The other varieties come in the following order according to their mean height: Seraup Kechil 36, second, with a mean height of 159.66 centimeters; Consejala, third, with a mean height of 155.84 centimeters; and Raminad strain 2, the lowest, with 154.98 centimeters. The differences in the mean height of plants of the four varieties were statistically significant, except the difference between the heights of Consejala and Raminad strain 2, which was insignificant. For the ratoon crop of the Thailand variety, the mean height of 90.22 centimeters was obtained.

Number of bearing culms per hill

There was no significant difference in the number of bearing culms per hill produced by the four varieties. The ratoon crop of Thailand gave a mean number of bearing culms per hill of 33.0.

[3] Uichanco, L. B. 1946. Annual report of the College of Agriculture for the academic year ending June, 1946. (Mimeographed)

Age at flowering and maturity

The ages at flowering of the five varieties and the maturity of the grains of four of them that the writers noted were as follows: Seraup Kechil 36 flowered in 149.6 days and matured in 177 days; Quezon rice flowered in 138.6 days and matured in 171 days; Raminad strain 2 flowered in 142.6 days and matured in 175 days; and Consejala flowered in 134.6 days and matured in 165 days.

The plant crop of Thailand flowered in 107.6 days after it was sown in the seedbed. The maturity of the plants of this variety could not be determined because the crop was totally destroyed by various pests while the grains were in the milk and dough stages. The ratoon crop, however, flowered in 140.3 days and matured in 180.3 days.

Yield. The actual yield per plot of each of the four varieties is shown in table 1. An analysis of variance showed that the differences in yield between the varieties are highly significant. Seraup Kechil 36, with a mean yield of 84.8 kilograms, gave the highest yield. Quezon rice, with a mean yield of 48.6 kilograms, ranked second; it gave a higher yield than either Raminad strain 2 or Consejala. There was no significant difference between the yields of Raminad strain 2 and of Consejala.

Based on actual yields obtained from the plots, the computed yield per hectare of Seraup Kechil 36 was 64.24 cavans, Quezon rice, 36.8; Raminad strain 2, 31.8; and Consejala, 16.21. The computed percentages of empty grains per variety were as follows: Thailand, 13.5; Consejala, 9.02; Raminad strain 2, 7.36; Seraup Kechil 36, 6.95; and Quezon rice, 6.22. These empty grains represented mostly those that were attacked by pests, particularly the rice bug.

That Seraup Kechil 36 gave the highest yield may be attributed partly to its ability to produce more plump and filled grains and heavier panicles. This variety ranked second lowest in the percentage of empty grains produced and second highest in percentage of filled grains. As a matter of fact it exhibited the highest degree of lodging, owing to its heavy panicles. Moreover, Seraup Kechil 36 sustained the least damage from pests as it matured about a week later than the rest of the varieties and because its harvest coincided with that of the majority of the rice crops in the surrounding fields.

The extremely low yield of Thailand may be attributed to several causes, one of which is that only the ratoon crop was harvested. This variety was destroyed by various pests, owing to its being the only variety in the field in the reproductive stage at the time when the pests were very active. Its being a semiglutinous and aromatic variety might partly account for its high susceptibility to pests. A mean yield of 1.9 kilograms per plot of 300 square meters, or a computed yield of 1.43 cavans per hec-

tare, was harvested from the ratoon crop that subsequently developed from the destroyed plant crop. The low yield may also be attributed to the delayed transplanting, which was 49 days after sowing in the seedbed. Escarrilla[4] found that the yield of Seraup Kechil 36, a variety that matures in 175 to 180 days, decreased as the planting time was delayed, and that the best age to transplant it was 20 to 30 days after sowing in the seedbed. The formation of nodes noted in some of the seedlings at the time of transplanting may also be another factor contributing to its low yield. Bautista[5] reported that the crop yield decreases if the rice seedlings are transplanted after they have produced nodes.

Milling percentage

Raminad strain 2 scored the highest percentage of milling with its 67.9 per cent; Consejala, 62.50; Seraup Kechil 36, 62.33; and Quezon rice, 61.11. From the available harvest of Thailand, the milling percentage of 67.34 was obtained.

SUMMARY

1. Of five varieties of lowland rice studied, Seraup Kechil 36, Quezon rice, Thailand, Consejala, and Raminad strain 2, the plant crop of the Thailand variety was a total loss owing to the severe attack of various pests. Only its age at flowering and the performance of the ratoon were obtained.

2. Of the four remaining varieties, Quezon rice (Raminad strain 3) was the tallest, with a mean height of 168.03 centimeters. Seraup Kechil 36 measured 159.66 centimeters; Consejala, 155.84; and Raminad strain 2, 154.98.

3. The differences in the mean number of bearing culms per hill of the four varieties were insignificant.

4. Thailand flowered in 107.6 days, but maturity of the grains could not be determined because they were totally destroyed in the milk and dough stages. Quezon rice flowered in 138.6 days and matured in 171 days after being sown in the seedbed; Raminad strain 2 flowered in 142.6 days and matured in 175 days; Seraup Kechil 36 flowered in 149.6 days and matured in 177 days; and Consejala flowered in 134.6 days and matured in 165 days.

5. All of the five varieties were attacked by pests and a fungous disease, but Thailand suffered the most and Seraup Kechil 36, the least. Seraup

[4] Escarrilla, Agustin M. The effect of age of transplanting seedlings upon the yield of Seraup Kechil 36 rice. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, 1941. Unpublished).

[5] Bautista, B. R. The general practice of lawland rice farming on irrigated areas in central Luzon. Agric. Indust. Monthly 3: 3, 13, 31.

Kechil 36 lodged the most, Quezon rice (Raminad strain 3) and Raminad strain 2 lodged heavily also, Consejala lodged but very slightly, and Thailand did not lodge at all.

6. The four varieties varied significantly in their yields. Seraup Kechil 36 gave a computed yield of 64.24 cavans per hectare; Quezon rice, 36.8; Raminad strain 2, 31.8; and Consejala, 16.21.

7. Raminad strain 2 gave a milling percentage of 67.90; Consejala, 62.50; Seraup Kechil 36, 62.33; and Quezon rice, 61.11.

8. The ratoon crop of the Thailand variety had a mean height of 90.22 centimeters, a mean number of 33.0 bearing culms per hill, a computed yield of 1.43 cavans per hectare based on actual yield, and a milling percentage of 67.39. It flowered in 140.3 days and the grains matured in 180.3 days.

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TABLE 1

Comparative yield in kilograms of clean palay of the four varieties

PLOTS	VARIETIES				TOTAL	MEAN
	Consejala	Raminad strain 2	Quezon rice	Seraup Kechil 36		
I	28.0	20.2	29.3	71.5	149.0	37.25
II	27.5	50.6	59.0	88.7	225.8	56.5
III	8.5	55.4	57.4	94.4	215.7	28.92
Total	64.0	126.2	145.7	254.6		
Mean	21.3	42.1	48.6	84.8	590.5	23.94

Analysis of Variance

SOURCES OF VARIATION	DF	SUM OF SQUARES	VARIANCE	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	*1%*
Plot	2	870.26	435.13	2.76	5.14	10.92
Variety	3	6,299.84	2,099.94	13.29	4.76	9.78
Error	6	947.99	157.99			
Total	11	8,118.09				

$$\text{L.S.M.D.} = 2.447 \sqrt{\frac{2\ (\text{Error variance})}{N}}$$

$$= 25.106$$

A COMPARATIVE STUDY OF CERTAIN CHARACTERISTICS OF FIRST-YEAR STUDENTS IN AGRICULTURAL, RURAL, AND ACADEMIC HIGH SCHOOLS[1]

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Much attention has been directed in recent years to the modification of our secondary-school curriculum in an attempt to make the secondary school meet adequately the needs of the students. In determining the nature of changes that should be introduced in the curriculums, it is necessary to know the kinds of students that enter the various types of high schools.

Review of literature

Although several studies have been conducted regarding secondary-school students, very few investigations have been made on the characteristics of first-year students in agricultural, rural, and academic high schools.

Sacay (1938) studied the occupational background and vocational choice of academic high-school seniors and found that 51.1 per cent of their fathers were farmers and 12.8 per cent were engaged in commerce. Of students who did not intend to enter college, 27.9 per cent planned to engage in farming; 14.5 per cent, in business; and 13.3 per cent, in military work. Of those who intended to go to college, 15.1 per cent wanted to become farmers; 14.4 per cent, lawyers; 9.1 per cent, doctors; and 9.6 per cent, engineers. Only a small percentage of the seniors wanted to pursue the occupations of their fathers.

In a study of the occupational choice of agricultural high-school seniors, Sacay (1933) found that 37.8 per cent intended to farm immediately after schooling and 24.1 per cent, after accumulating sufficient capital.

Magtira (1937) reported that 14.1 per cent of the U. P. High School seniors intended to study law; 6.52 per cent, business; and 2.2 per cent, agriculture.

The principal object of the present investigation, which was started in 1940 and completed in 1941, was to determine the characteristics of students that enter the agricultural, rural, and academic high schools, particularly: (*a*) the districts from which they are drawn, (*b*) the occupational groups to which their parents belong, (*c*) their vocational interests, and (*d*) their recreational preferences.

[1] Experiment Station Contribution No. 1489.

MATERIALS AND METHOD

The study included 2,551 first-year students who were enrolled in 36 high schools during the 1940-41 school year and distributed as follows: 585 first-year students in agricultural high schools in 9 provinces and 655 students attending academic high schools in those provinces; 537 rural high-school students in 9 provinces and 774 students in academic high schools located in the same provinces. The agricultural high schools were located in Agusan, Camarines Sur, Isabela, Lanao, Leyte, Mountain Province, Nueva Ecija, Palawan, and Sulu. The rural high schools were located in the provinces of Albay, Bohol, Capiz, Cavite, Ilocos Norte, Nueva Vizcaya, Pangasinan, Romblon, and Zambales. In some of these provinces, the academic high schools had started offering the general curriculum.

Copies of a questionnaire prepared by the investigators were sent to the principal of each of the 36 high schools, who was requested to have the questionnaire filled by the students in 2 typical sections of the first year. The filled questionnaires were then returned to the investigators.

RESULTS

Sex of students

There was a preponderance of male students in both agricultural and rural high schools. In the former, 75.2 per cent of the students were male and in the latter, 78.2 per cent. Only about one-fourth of the students in these schools were female. In the case of the academic high schools, the proportion of male was only slightly higher, the percentage being 53.8.

Age of students

The first-year students in the agricultural high schools were older than those in the other schools, especially the academic. The average ages were as follows: agricultural, 16.8 years; rural, 16.3; and academic, 15.0.

The boys were older than the girls in all types of schools, the difference being biggest in the agricultural schools, where it was 2.5 years. In both the rural and academic high schools, the boys were only 0.8 year older than the girls.

Ratings in Grade VII

The ratings which the students obtained in Grade VII ranged from 75 to 95 per cent. Students in the academic high schools had an average rating of 81.8 per cent, which was higher than the 80.7 per cent of agricultural high-school students, or the 79.7 per cent of the rural high-school students. In the same school, the difference in the average rating of the boys and of the girls was very small.

Districts from which students were drawn

The majority of the students who entered the agricultural high schools were residents of farm villages; only 39.0 per cent were residents of the town proper. In the rural high schools, the percentage of students from the town was slightly higher (45.0 per cent). On the other hand, the academic high schools were attended to a large extent by residents of the town, the percentage being 59.1.

Occupational groups from which drawn

About three-fourths, or 75.9 per cent, of students who entered agricultural high schools were children of farmers. The rural high schools were also largely attended by farmers' children, the percentage being 60.4. On the other hand, only 35.1 per cent of those who entered the academic high schools had farmer parents. Employees' children formed 14.6 per cent; merchants', 8.8 per cent; and teachers', 6.5 per cent. Parents belonging to these occupational groups did not send to agricultural and rural high schools as many children as they did to academic high schools.

Ownership of farms

The majority of the parents of agricultural students were farm owners. Only 18.2 per cent of parents of agricultural high-school students and 25.2 per cent of parents of students in the rural high schools did not own farms. In the case of parents of academic high-school students, 49.1 per cent were not farm owners.

Occupational intention of students

While a large proportion of the students in academic high schools intended to engage in professional work, it was not the case with agricultural students. Of the male students who entered the agricultural high schools, 80.0 per cent selected farming as their future occupation, and 8.2 per cent wanted to become teachers (table 1). These figures indicate that those who attended agricultural high schools were generally interested in farming. In the case of the rural high-school students, 70.5 per cent selected farming. Many students chose nonfarming occupations. About 8.6 per cent wanted to become engineers; 5.3 per cent, teachers; and 3.1 per cent, soldiers.

In the academic high schools, the majority of the first-year boys selected nonagricultural occupations. Only 21.4 per cent wanted to become farmers. In terms of per cent, the number that wanted to become soldiers was 11.9; teachers, 10.9; businessmen, 10.4; engineers, 8.0; aviators, 5.0; doctors, 3.4; and lawyers, 3.0.

In the case of the girls, only 22.8 per cent of those who entered the agricultural high schools planned to engage in farming. In the rural high

schools, the percentage was only 5.1. These figures show that agricultural training would prove of occupational value to only a small number of the girls, as about 40 per cent wanted to become teachers. About one-third of the girls in the agricultural high schools wanted to become dressmakers, nurses, or housekeepers. In the rural high schools, these three occupations were selected by 43.8 per cent of the girls.

As was to be expected, only a negligible number, 1.9 per cent, of the girls in academic high schools selected farming. Teaching was the most popular, being chosen by 46.8 per cent. Many girls wanted to become nurses, merchants, housekeepers, and dressmakers. These occupations were selected by 36.3 per cent of the girls.

Proportion of children intending to follow parents' occupations

In the agricultural high schools, 81.7 per cent of farmers' sons desired to follow their fathers' occupation. Among the rural high-school students, the percentage was 75.3. Of the farmers' sons who entered the academic high school, only 35.2 per cent desired to become farmers.

In the other occupational groups, only a very small percentage of sons intended to engage in the occupations of their fathers.

Recreational preferences

About half of the first-year students in the different types of secondary schools preferred to read newspapers, magazines, and books during their leisure time. The other recreational activities selected by a large number were playing group games and going in for athletics. Agricultural students liked gardening. Among girls, sewing and embroidery were popular.

SUMMARY

1. About three-fourths of the first-year students in the agricultural and rural high schools surveyed were male. In academic high schools included in the survey, there were almost as many girls as boys.

2. Students in the agricultural high schools were 1.8 years older than those in the academic high schools, and 0.5 year older than those in the rural high schools. The boys were older than the girls in each type of school, especially in the agricultural high schools.

3. Students who entered the academic high schools had a slightly higher seventh-grade rating than those who enrolled in the agricultural and rural high schools.

4. The majority of the students in the agricultural high schools were from the barrio. In the academic high schools, more students came from the town.

5. The students in the agricultural and rural high schools were, in the majority of cases, children of farmers. In the academic high schools, only 35.1 per cent of the students were farmers' children.

6. A large proportion of parents of agricultural students were farm owners. Only about half of the parents of students in the academic high schools owned farms.

7. About 80.0 per cent of the male students in the agricultural high schools and 70.5 per cent in the rural high schools selected farming as their future occupation. In the academic high schools, only 21.4 of the students wanted to engage in farming. A large number selected business and professional pursuits.

8. Even in the agricultural and rural high schools, a small number of girls intended to engage in farming, the percentage being 22.8 and 5.1, respectively. The majority wanted to become teachers, nurses, dressmakers, and housekeepers. This was also the case with the girls in the academic high schools. Only 1.9 per cent of the girls wanted to engage in farming.

9. Of farmers' children enrolled in the agricultural and rural high schools, more than three-fourths selected farming as their future occupation. Of farmers' children who entered the academic high schools, only 35.2 per cent intended to farm.

10. The most popular recreational activity of students in all types of schools was reading. Group games and athletics were also frequently mentioned.

LITERATURE CITED

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TABLE 1

Occupational intention of students

OCCUPATIONAL INTENTION	MALE STUDENTS			FEMALE STUDENTS		
	Agricultural high schools	Rural high schools	Academic high schools	Agricultural high schools	Rural high schools	Academic high schools
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Farmer	80.0	70.5	21.4	22.8	5.1	1.9
Businessman, merchant	2.3	2.1	10.4		4.2	8.2
Teacher	8.2	5.3	10.9	40.0	39.4	46.8
Soldier	1.6	3.1	11.9			
Mechanic	2.3		2.2			
Employee	1.6	.5	1.6			
Forester	1.1	1.7	.4			
Engineer	.4	8.6	8.0			
Carpenter	.7	2.5	.8			
Radio operator	.5	.5	1.6	.7	.2	
Aviator		1.4	5.0			
Sailor			1.6			
Doctor			3.4			1.0
Lawyer		.9	3.0	.7		
Stenographer, clerk		.5	1.4		.2	1.2
Fisherman		.2	1.3			
Dressmaker				12.4	14.6	7.0
Nurse				11.0	8.6	13.5
Housekeeper				11.7	20.6	7.6
Pharmacist				.7		3.0
Others	1.3	2.2	15.1		7.1	9.8
	100.0	100.0	100.0	100.0	100.0	100.0

BROODINESS AMONG LOS BAÑOS CANTONESE LAYERS[1]

F. M. Fronda and Precillano C. Campos
Of the Department of Animal Husbandry

Broodiness is the tendency of female birds to incubate their eggs after they have laid a sufficient number for them to cover efficiently. Being an individual characteristic, its presence or absence in a hen will influence the number of eggs she can lay. The Los Baños Cantonese is generally recognized as a broody breed, but to what extent this characteristic may be present in the individual birds has not yet been determined. This study was made to determine how frequent Los Baños Cantonese layers become broody during the year, and how long it takes the hen to return to production after the broody period. It was conducted from July, 1942, to July, 1943.

PLAN OF THE STUDY

The layers were carefully observed for the occurrence of broodiness. The first time a hen became broody, it was provided with a blue celluloid leg band; the second time, another blue leg band was added. The third time, however, the two blue leg bands were replaced with a red leg band. Thus, one blue leg band on the leg of a hen indicated that it had been broody once, and one red leg band, three times.

The broodiness of some of the hens was broken up either by placing them in a broody coop or by confining them in a small pen with a rooster. In both cases, the length of time required to break up their broodiness was determined. Some of the broody hens were allowed to hatch their eggs. Some of the hens in this group were separated from their chicks immediately after hatching, while the others were allowed to brood their chicks until weaning. To determine how long a hen will remain broody if she is allowed to sit in the nest without eggs, all of the hens that became broody from January to March, the natural hatching season, were allowed to remain in their empty nests until they became tired and left of their own volition. In all cases, the number of days from the start of broodiness to the time the hens returned to production was recorded.

In addition to these observations, every bird that became broody was weighed daily at five o'clock in the afternoon throughout the period of

[1] Experiment Station Contribution No. 1490. Read before the seventy-third regular scientific meeting of the Los Baños Biological Club held on November 21, 1947. The data presented in this paper were taken from the thesis presented in 1944 by the junior author for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, University of the Philippines.

broodiness. The body temperature was taken with a clinical thermometer at the onset of broodiness and every day thereafter during the broody period and for three days one week after. The hemoglobin content of the blood was determined with the use of the "Improved Newcomer Model" hemoglobinometer before a hen showed signs of broodiness, and then every other day during the time of broodiness until one week after the broody period.

RESULTS AND DISCUSSION

Frequency of broodiness. The results obtained showed that of the 260 hens observed, 131, or 50.4 per cent, did not become broody during the year, while the rest, 129 hens, or 49.6 per cent, became broody at various periods, the broodiness ranging from one to five times during the year. Among the hens that became broody, there was no difference in the percentage of broodiness among groups of different ages, but there was a significant variation in the frequency of broodiness between individuals. It was observed that of the hens that became broody, 37.2 per cent were broody once, 33.3 per cent were broody twice, and 20.9 per cent, thrice. Very few, 6.2 per cent of the flock, became broody four times, and only 2.3 per cent were broody five times. These figures seem to show that, contrary to the general belief, the Los Baños Cantonese is not a very broody breed.

The figures obtained in this study also showed that the percentage of Los Baños Cantonese hens that were broody during the different months of the year did not vary among the groups of hens of different ages. The percentage that became broody during each month, however, varied significantly. More hens became broody during the months of February (13.7 per cent of the flock), March (19.0 per cent), and April (15.6 per cent). Broodiness was also fairly high in May, August, and September, when it was 12.5, 11.4, and 12.5 per cent, respectively. Broodiness was low in the following months as indicated by the percentages: June, 5.4 per cent; July, 5.0 per cent; October, 3.4 per cent; November, 9.0 per cent; December, 7.5 per cent; and January, 7.4 per cent. The statement of Fronda[2] that broody hens are a nuisance, especially during hot months, was confirmed by the results obtained in this study.

Duration of broodiness. Broody hens confined in a broody coop required 6.3 ∓ 0.5 days to break up their broodiness, and those confined in a pen with a rooster, 7.6 ∓ 0.6 days. These figures do not differ significantly. They imply that confining broody hens either in a broody coop or in a pen with a rooster are equally effective in breaking up broodiness. The broody hens that were allowed to stay in the nests without eggs to hatch had a mean broody period of 13.5 ∓ 1.3 days.

[2] FRONDA, F. M. 1941. Poultry raising. xxx + 439 p. 125 fig. Manila: Oriental Commercial Company, Inc.

Return to production. It took the Los Baños Cantonese hens from 24.7 ∓1.5 days to 101.8∓7.1 days to return to production, depending upon the manner the broody hens were treated. Hens confined in the broody coop to break up their broodiness returned to production in 28.5∓1.8 days, whereas those that were confined in a pen with a rooster returned to production in 24.7∓1.5 days. The broody hens that were allowed to stay in empty nests did not return to production until after 32.6∓2.3 days. There is no significant difference among these figures. The birds that were allowed to hatch their eggs and were separated from their chicks immediately after hatching returned to production in 66.5∓3.7 days. It needed 101.8∓7.1 days for the hens that were allowed to hatch their eggs and take care of their chicks till weaning to return to production. These figures show definitely that, as pointed out by Rice, Hall, and Marble (1930),[3] broodiness causes periods of complete cessation of production, the lengths of which vary in Los Baños Cantonese hens from 24.7∓1.5 days to 101.8∓7.1 days, depending on whether the broodiness was broken up or the hen allowed to hatch her eggs and brood her chicks to weaning age.

Characteristic changes in the hen that becomes broody. Observations showed that the approach of broodiness was first indicated by the hen's dropping some feathers from her abdominal region. These feathers were conspicuously noticeable in the nests. The broody hens remained in the nest at all times. They became generally vicious and clucked and ruffled their feathers when approached. They ate and drank sparingly, remained still, and had practically no exercise.

Los Baños Cantonese hens generally lost in weight when they became broody, and the longer the duration of broodiness, the greater the loss in weight. Hens that sat on their eggs were observed to decrease in weight from the onset of broodiness until the eggs were hatched. After hatching, the hens with broods were observed to pick up weight and regain their normal weight before the chicks were weaned.

The body temperature of the broody hens did not vary more than one degree centigrade during and after broodiness. It was also observed that the body temperature of broody hens did not vary significantly from their body temperature when they were not broody. On the other hand, the hemoglobin content of the blood had a tendency to decrease gradually during the period of broodiness but returned to normal one week after the broody period.

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[3] Rice, James E., Golden O. Hall, and Dean R. Marble. 1930. Judging poultry for production xxii + 425 p. 205 fig. New York: John Wiley & Sons, Inc.

SUMMARY

1. Of the 260 Los Baños Cantonese hens observed, 50.4 per cent did not become broody during the year. This figure seems to indicate that the Los Baños Cantonese is not a very broody breed.

2. Of the 129 Los Baños Cantonese hens that became broody, a great majority, 70.5 per cent, became broody only once or twice during the year.

3. More hens were observed to become broody during the hot months of the year than during the cooler months.

4. Confining broody hens either in a broody coop or in a pen with a rooster broke up broodiness in about the same length of time, 6.3∓0.5 days for the former and 7.6∓0.6 days for the latter.

5. The number of days that elapsed from the onset of broodiness to the return to production did not vary significantly, whether the hens were confined in a broody coop (28.5∓1.8 days), confined in a small pen with a rooster (24.7∓1.5 days), or allowed to stay in the nest without eggs (32.6∓2.3 days).

6. The hens allowed to hatch their eggs but were separated from the chicks immediately after hatching returned to production in 66.5∓3.7 days, while those that were allowed to hatch and brood their chicks to weaning age did not return to production until after 101.8∓7.1 days from the onset of broodiness.

7. There was no significant difference in body temperature of the hen when it was broody and when it was not.

8. In general the Los Baños Cantonese hens lost weight when they became broody, and the hemoglobin content of the blood decreased as the period of broodiness continued but tended to return to normal one week after.

COLLEGE AND ALUMNI NOTES

The Society for the Advancement of Research (SAR), an honorary scientific society of the College, met on July 18, 1947, for the first time since the outbreak of the war in 1941 and elected the following officers for the school year 1947-1948: Dr. José M. Capinpin, president; Professor Calixto Mabesa, vice-president; Dr. Nicolas L. Galvez, secretary, and Dr. Silverio M. Cendaña, treasurer. The members of the society present in the meeting were Dean L. B. Uichanco, Drs. F. M. Fronda, F. M. Sacay, Julian Banzon, Eulalio P. Baltazar, J. M. Capinpin, N. L. Galvez, V. C. Calma, G. O. Ocfemia, and Professors C. Mabesa and E. F. Roldan.

With Dr. Valeriano C. Calma as president for the school year 1947-1948 and Dr. Nicolas L. Galvez as secretary, the Los Baños Biological Club resumed its regular prewar scientific activities and scheduled the one-hundred-and-seventieth scientific meeting on Friday afternoon, August 22, 1947, at 4:15 o'clock in the Agricultural Engineering Lecture Hall. The following papers were read and discussed: "Making Corn-Tapilan Silage" by Mr. José P. Esguerra, of the Department of Animal Husbandry; and "On a Chemical Basis for the Conversion of Coconut Oil into Hydrocarbons" by Dr. Julian Banzon, of the Department of Agricultural Chemistry. In its one-hundred-and-seventy-first meeting held on September 19, 1947, in the same place, the following papers were discussed: "A Study of the Introduced Rambutan Trees in the College of Agriculture" by L. G. Gonzalez and B. R. Luardo, of the Department of Agronomy; and "A Study of the Effect of Hog Cholera on the College Swine Herds" by Dr. M. Mondoñedo, of the Department of Animal Husbandry.

In a letter to Dean L. B. Uichanco, Major General George F. Moore, Commanding General of the PHILRYCOM, expressed his appreciation of the splendid services rendered to the war internees by the officials of the College. The communication was written in connection with a letter sent to the PHILRYCOM by Mr. L. H. Golucke, one of the Allied prisoners of war interned in Los Baños, who acknowledged the "much needed aid and assistance" rendered by the officials of this institution.

In another letter to Dean Uichanco, Major General Moore enclosed a copy of Mrs. Harriett L. Richards' letter commending the professors and students of the College for the splendid service rendered to her and to other Allied internees in Los Baños during the last war. Among those specifically mentioned in Mrs. Richards' letter, together with their contributions and assistance given, were President Gonzalez, Dean Uichanco, Dr. L. G. Gonzalez, and Mrs. F. Roa.

Dr. Benjamin J. Birdsall, principal agriculturist in the Technical Collaboration Branch of the Office of Foreign Agricultural Relations, U. S. Department of Agriculture, was a recent visitor on the campus. He was accompanied by Mr. Francisco R. Red, '19, of the Technical Division, NAFCO. Dr. Birdsall conferred with Drs. Pedro A. David and Gerardo O. Ocfemia on abacá culture and abacá diseases. Since July, 1947, Dr. Birdsall has been studying the Philippine abacá situation at the request of the Philippine government. He left for the United States on September 18, 1947.

With His Excellency, Vice President Elpidio Quirino of the Philippines as the guest of honor, the twenty-ninth Loyalty Day was celebrated on October 10, 1947. The whole-day celebration consisted of a parade and a program in the morning, a luncheon, basketball games in the afternoon, and a dance in the evening. Of the six floats entered in the parade, the Animal Husbandry Department won first place, the U.P. Rural High School, second, and the Agronomy Department, third. Vice President Quirino was the principal speaker in the program which was held after the parade. He was introduced by U.P. President Bienvenido M. Gonzalez. Dean Uichanco administered the oath of loyalty. The musical numbers in the program were furnished by the Camp Murphy Band conducted by Capt. L. G. Cariño and Misses Pilar Benavidez, Esperanza Estrella, and Andrea Hofilada, students from the U.P. Conservatory of Music. A record crowd at the basketball games witnessed the defeat of the players of La Salle by the Aggie alumni, and of the U.P. Los Baños by the U.S.T. dribblers. The winning teams were awarded cups donated by the then Governor Juan Pambuan and Atty. Dominador Chipeco. The students' loyalty dance in the evening ended the celebration, a rainless one in many a year.

The alumni attendance in the Loyalty Day celebration was the biggest in many years. More than one hundred alumni, excluding those connected with the College of Agriculture, participated in the festivities. Practically all classes were represented, as may be seen in the following list: 1911 — Manuel L. Roxas; 1913 — B. M. Gonzalez; 1914 — Gonzalo Merino; 1915 — José Q. Dacanay; 1916 — Marcelino Constantino, José de Leon; 1917 — Hilarion S. Silayan; 1918 — Santiago Festin, Ramon V. Manio, Faustino Q. Otanes, Leon M. Romero, A. L. Teodoro; 1919 —José Noguerra, F. de Peralta, Francisco R. Red, E. F. Roldan, F. B. Serrano, D. V. Villadolid; 1920 — Nemesio Catalan, Gregorio D. Cazeñas, Feliciano M. Clara, Rufino Isidro, Gaudencio M. Reyes; 1921 — Julian A. Agati, Victor C. Aldaba, Artemio Manza, Severino Marquez, P. A. Rodrigo, Pedro Sison; 1922 — Crispulo G. Bagui, Basilio Hernandez, Anacleto R. Peliño, Quirino P. Ricafrente, Basilio O. Viado; 1923 — Ramon A. Cruz; 1924 — Canuto Manuel, Francisco P. Pañganiban, Francisco Ramos; 1925 — C. V.

Crucillo, Victor T. Feliciano, Moises Kalaw, Pablo Quizon, Gonzalo Salazar; 1927 — Dionisio A. Calvo, Quintin A. Eala, Antero P. Inciong, Primitivo Tugade; 1928 — Catalino P. Javier, Felix F. Villa, Dimas Maulit; 1929 — Alfonso E. Briones, M. S. Celino; 1930 — A. E. Gesmundo, J. P. Mamisao, Ricardo T. Marfori; 1931 — Santiago R. Capco, Pantaleon L. Dumlao, Francisco S. Gomez, Marcos A. Vega; 1932 — Gregorio S. Chan, Andres M. Mane, Juan F. Villarroel, Jr.; 1933 — José T. Alhama, Pacifico L. Bautista, Bartolome P. Javier, Salvador B. Oliveros, P. F. Ortiz; 1934 — Felipe T. Aala, Victorino Borja, Maximino S. Cortez, Fernando Mabalay, Nicomedes C. Reyes, Alfonso L. Tecson, Constante V. Valera; 1935 — L. A. Alicbusan, Alberto C. Felix, Floro Flores, Abel Silva; 1936— Nicanor M. Alvaro, Aquilino V. Platon, Ernesto T. Rigor, Demetrio S. Santos; 1937 — Amando M. Dalisay, Conrado Dinulos, M. Manresa, Jr.; 1938 — Trinidad Q. Alconcel, Juan C. Fandialan, Ramon G. Mercado, Lazaro A. Ocampo; 1939 — Severino Hermosura, A. L. Madamba, José P. W. Tantoco, Ascario G. Tuason; 1940 — Agustin Mañgila, Potenciano C. Reaño; 1942 — Miguel B. Cosico, Antonio A. Maclan; 1943 — Elpidio Galado; 1944 — Francisco Gachalian; 1945 — Rodolfo V. Aquino, Edmundo Villegas; 1946 — Abelardo Baclig, M. E. Fronda, R. H. Ocfemia, Manuel A. Velarde; 1947 — Lydia V. Catalan, German M. Cruz, Ciriaco M. Lawas, Jesus Moran Sison, and Herminio W. Tantoco. Many alumni are not included in the list owing to their failure to sign the guest book.

Mr. Frank Gaines, director of the UNRRA in the Philippines, and his party attended the Loyalty Day celebration.

The final examinations for the first semester 1947-1948 were held from October 14 to October 17, 1947. Registration began on October 29 and classes for the second semester started on November 3, 1947.

On October 24, 1947, the faculty approved to recommend to the University Council the graduation of the following students: Doroteo C. Asuncion, Enrique O. Bondoc (*magna cum laude*), Solomon G. Cabrera, Apolinario R. Carañgal, Jr. (*cum laude*), Saturnino G. Cauton, Gregorio C. Fernandez, Leonardo L. Gantioqui, Ponce Blas H. Infante, José B. Julian, Tomas L. Mañgasep, Felix Maramba, Jr., Maximino C. Reaño, Atanacio A. Simon, Luz A. Uichanco (*magna cum laude*), and Cesar A. Villariba.

Through the efforts of the Honorable Undersecretary José S. Camus, '14, the College recently received the following machinery allocation from the UNRRA: one 3-28-inch disk plow, two 2-28-inch disk plows, one 7-foot double-disk plow, one 4-section peg-tooth harrow, one 12-foot cut Massey-Harris rice combine, one 15-30 h.p. McCormick-Deering tractor, and one 10-20 h.p. McCormick-Deering tractor.

Dr. Eduardo Quisumbing, '18, was appointed director of the National Museum by President Roxas. Dr. Quisumbing was formerly chief of the

Natural History Museum, a division of the Department of Agriculture and Commerce, which was recently raised to the rank of bureau. He was for some time an assistant professor in the Department of Agricultural Botany of the College. He obtained his degree of doctor of philosophy from the University of Chicago.

Mr. Nathaniel B. Tablante, '46, arrived from the United States on October 21, 1947, after a year's stay at Cornell University, where he received a master's degree, with major in agricultural economics, as a Huffcutt scholar. He reported for duty on November 3, 1947, as instructor in agricultural economics.

The one-hundred-and-seventy-second scientific meeting of the Los Baños Biological Club was held on November 7 at the Agricultural Engineering Hall to discuss the following papers: "Morphogenetic Effects of 2, 4-D on Some Crop Plants" by Mr. Cesar A. Villariba and Dr. J. M. Capinpin, of the Department of Agricultural Botany; and "A Study of the Agronomic Characteristics and Yield of Eleven Varieties of Sweet Potato" by Dr. V. C. Calma and Mr. F. S. Zamora, of the Department of Agronomy. The one-hundred-and-seventy-third meeting held on November 21, 1947, at 4:15 o'clock took up the following papers: "Broodiness among Los Baños Cantonese Layers" by Dr. F. M. Fronda and Mr. Precillano C. Campos, of the Department of Animal Husbandry, and "Effects of Photoperiod upon the Upland Rice Plant, Variety Inintiw" by Mr. Burton T. Oñate of the Department of Agricultural Engineering and Dr. R. B. Espino of the Department of Agricultural Botany.

The second semester opened in the Rural High School on November 3, 1947, with an enrollment of 212, or 14 less than the number in the first semester. Some of the students discontinued their studies, while others transferred to other schools.

A reading club was recently organized by several members of the faculty for the main purpose of enabling them to read more books and magazines at the least cost to the individual member. Contributions will be collected from the members from time to time as additional funds are needed. Professor Aurora L. Samonte was unanimously chosen manager of the club.

Dr. F. M. Sacay was recently appointed member of the Philippine Committee of Food and Agriculture, which is a national liaison organization between the Philippines and the Food and Agriculture Organization of the United Nations.

THE EXPERIMENT STATION

LIST OF AVAILABLE CIRCULARS AS OF MARCH, 1948

No. 2.—Bud Rot of Coconut..... *By G. O. Ocfemia*

No. 8.—Horse Breeding in the Philippines..... *By V. Villegas*

No. 10.—Practical Directions for Coffee Planting..... *By Pedro A. David* (Revised by Charles Fuller Baker, Dean, College of Agriculture, 1917–1927.)

No. 11.—The New College Copra Drier—Prepared in the Department of Agricultural Chemistry with the Cooperation of the Department of Agronomy and Extension. (Revised)..... *By Moises M. Kalaw*

No. 16.—A Simple Farm Record for the Farmer..... *By F. M. Sacay*

No. 17—College Trapnest..... *By F. M. Fronda and P. S. Paje*

No. 18.—Surveying for Area with a Surveyor's Staff.. *By Alexander Gordon*

No. 20.—Amount of Nutrients in Philippine Food Materials..... *By F. O. Santos and S. J. Ascalon*

No. 23.—Curing Pork and Making Sausage for Home Use..... *By Mariano Mondoñedo*

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